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Exploring the Viability and the Impact of Participatory Plant Breeding from Seed to Table

Shelley Spruit

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SCHOLAR PROFILE

SHELLEY SPRUIT has a long relationship, diverse history, and serious passion for working with grain. For the last 30 years she has been a grain farmer, baker and chef, and ancient grain restorer and researcher learning about Participatory Plant Breeding and the potential for the Canadian farmer.

Five years ago, concerned with the loss of agriculture biodiversity and seed availability for grains, Shelley began the venture that lead her to found Against the Grain Farms. With persistence, she works to adapt ancient grains from around the world to the Ontario climate.

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To my husband Tony who encouraged me to apply for the scholarship.
To the many wonderful farmers that I met throughout my 2018 year of travels.
To the hosts that happily gave me a place to lay my head during my travels.
To the plant breeders, researchers, professors willing to share their experience with PPB.
To Sharon Johnson who helped me get my thoughts, experience and conclusions onto paper.
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SPONSORSHIP

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EXECUTIVE SUMMARY

My concern is that Canadian farmers remain competitive and market-adaptable, resilient and financially viable in the face of climate change. Seed line selection is a key part of plant breeding. Participatory Plant Breeding (PPB) involves farmers as active partners with research stations in this selection throughout the breeding process.

Two questions undergird my Nuffield-sponsored explorations:

1. How is Participatory Plant Breeding (PPB) a viable response for adapting to the challenges of climate change?
2. What impact is PPB making in agroecology's heritage grain networks from seed to table?

Until recently, most participatory plant breeding (PPB) programs were located in developing countries and their practical relevance for developed agricultural systems was questioned. However, due to the increase in dramatic climate changes now facing Canadian farmers , PPB grain research is quickly emerging as a highly relevant and necessity-driven response to weather challenges. Because no single mechanism can guarantee resilience, PPB is able to increase genetic diversity conservation by ensuring farm participation in the crucial years of growing out the new varieties. Given unpredictable weather patterns, self-replicating seed stock contributes to greater seed adaptability and plant resilience within the Canadian food system.

Thanks to Nuffield, I probed PPB and various network partners in eleven countries, including attendance at four international conferences and a one-day Canadian conference. Within the climate change context, I discovered that PPB plays an important, contributory role in agroecology, an evolving transdisciplinary field strongly endorsed by the United Nations. PPB will also contribute to implementing Canada's new National Food Policy with its budgeted support for a Local Food Infrastructure Fund.

While all effective PPB developments are locally oriented by environmental necessity, PPB also requires food network partners. Thus, terroir identities and scaling niche markets serve as representative examples of important emerging trends awaiting further development.

To offer applications in the Canadian agriculture industry, I offer recommendations in three areas: participatory plant breeding projects; seed to table network partners and institutional or governmental policy making.

DISCLAIMER

This report has been prepared in good faith but is not intended to be a scientific study or an academic paper. It is a collection of my current thoughts and findings on discussions, research and visits undertaken during my Nuffield Farming Scholarship.
It illustrates my thought process and my quest for improvements to my knowledge base. It is not a manual with step-by-step instructions to implement procedures.
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In submitting this report, the Scholar has agreed to Nuffield Canada publishing this material in its edited form.

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1 INTRODUCTION

The urgency of climate change is particularly acute for Canadians, according to Catherine McKenna, Minister of the Environment and Climate Change, at the time of writing this report. This is because the scientific data shows that "Canada is warming at twice the global rate (CCCR 2019a p.84). It's three times higher in our north… we have to take big steps forward" (McKenna 2019). Participatory plant breeding (PPB) is one of those big steps, a step already being practiced in selected places in Canada and in the countries I visited as a Nuffield scholar. PPB has local, regional, national, and global levels of application, all of which need to be strengthened and more broadly supported. I strongly believe that its programs and practices are essential to basic food sovereignty, security and sustainability in the face of chaotic climate patterns.

Much of this introduction will focus on first presenting the significant work of PPB as it is being implemented in Canada at the present time. This will include the role of open source seeds and seed security and the importance of biodiversity. Other contexts also frame this section and the whole report, namely Climate Change, Agroecology, and Canada's National Food Policy. This contextual understanding of PPB's basic issues and practices will help to set the stage for the further explorations of PPB in other Countries (Section 2) I visited and the Conferences (Section 3) I attended as a Nuffield scholar.

Both at home and abroad, I discovered that there is a natural continuum based on the movement from seed to table that involves partnerships between farmers at one end, and other partners and consumers at the other end. In non-linear ways, partner innovations circulate in many interconnected networks. Therefore, Terroir Identities and Seed To Table Partners (Section 4.3) will explore these identities and partnerships as that relates to scalable and niche markets.

Because of my own experiences in learning to implement PPB, I have included a few vignettes based on the six years of experimental work I've undertaken at Against the Grain Farms. These vignettes appear at various points in the text, and particularly at the end of Terroir Identities and Seed to Table Partners, Section 4.3. As a PPB-oriented farmer working the whole of the seed to table network, I know the challenges of growing and of marketing my heritage grains and pulses. Just like farmers everywhere I need to make a living, one that is becoming more demanding given the climate chaos we all face.

Two study questions frame this report. 1. How is PPB a viable response for adapting to the challenges of climate change? 2. What impact is PPB making in agroecology's heritage grain

networks from seed to table? Please note that viability and impact are stated separately in their respective questions but both terms apply within each question. This is due to the fact that PPB always functions in relationships with overlapping partners, which will become clear within this report.

This report includes materials drawn from my visits to the following countries: Nicaragua, California and Oregon in the US, France, England, Scotland, Bologna and Rome in Italy, the Republic of Georgia, Estonia, Manitoba in Canada, Denmark, and Sweden. Visits included farms, research institutes, businesses, and conferences, and my travels are used selectively to explore a representative range of discoveries.

1.1 Participatory Plant Breeding in relation to Conventional Plant Breeding

My purpose in this report is to focus my primary attention on participatory plant breeding - it is the reason supporting my Nuffield travels. However, at the outset, it's important to be clear that though some critiques of modern agriculture, the Green Revolution, and its association with corporate and private plant breeding will be noted, these issues are raised in order to clarify PPB's distinctive features and practices. Though PPB had been historically implemented on small and medium scale farms, there are also numerous examples of significantly scaled up operations that will be shared at various places in this report. PPB methods very often apply in the many agricultural areas that are underserved by modern farming practices. Because of this underservice, there is a place for conventional approaches as well as the agricultural PPB contributions to the food system. Examples may be found in the 2003 report on Participatory Plant Breeding published by R. Vernooy (IDRC 2003). Of the 250,000 plant varieties available to agriculture, less than 3% are in use today (ibid, p3). Vernooy provides a "series of project stories from the Andes to the Himalayas and beyond". The research projects described in this report include all three major crop propagation types with a clear focus on the major staple crops: rice, beans, maize, and to a lesser degree sorghum. Many projects focus on two or more crops, including combinations of open-pollinated, self-pollinated, and clonally reproduced, as well as vegetables, fruits, and other crops. Multicrop farming systems and home gardens are also included.

The point of indicating some of the problems and challenges facing industrial agriculture is to help readers to understand why and how PPB is viable and able to make significant contributions to plant breeding, seed development, crop production and subsequent markets and value-added products. Though the focus of this report will be grains, PPB is also used for vegetable breeding and trialing.

In order to define and situate participatory plant breeding, it's important to know first of all that there is a current reinstatement and refocus on the farmers' considerable abilities as able plant breeding partners. Such farmer-breeder partnerships are gaining in justifiable credibility because the PPB methods and the resulting crops offer genuine alternatives and complements to some of the emerging problems of the Green Revolution.

As noted by Canadian researcher, Ronnie Vernooy, the very considerable success of the high-yield/ high-input megacrops (rice, wheat, maize, sorghum, millet, potatoes, and sweet potatoes) associated with the revolution has also created a number of serious problems (Vernooy 2003a). One is the serious marginalization of farmers along with their intimate knowledge of their crops and their land; another problem concerns the alarming rate of "genetic erosion". This topic of genetic erosion will be further discussed in The Bauta Family Initiative on Canadian Seed Security, Section 1.2

The renewed emphasis on farmer participation in PPB is a timely corrective to the mere *recipient* status of farmers at the bottom of the modern "top-down system of agricultural research" (Vernooy, 2003a). Another Canadian research team notes that the top-down approach of professional corporate plant breeders has contributed to the increasing 'isolation' between them and the needs of plant breeding farmers (Entz et al, 2018, citing Cleveland et al, 1994). PPB aims to remove the unjustified isolation and reinstate farmers as equal partners contributing to breeding and selection programs.

The scientific background to PPB selection practices by farmers has been supported by the work of Entz et al, 2018. It states the millennial-old precedent to say that a farmer's "direct selection in the target environment is always the most efficient" (Entz et al, 2018, citing Falconer, 1952). In the details of PPB that follow, it will become clear as to why the target environment is so important to seed and plant selection and to food sustainability.

1.2 Participatory Plant Breeding in Canada

The Figure 1 that follows details the differences between a traditional breeding program and the Participatory Breeding Program as practiced at Natural Systems Agriculture at the University of Manitoba (UManitoba, n.d.). While it's important to note that there is 'no one size fits all' in the PPB world, this diagram shows the approach presently being taken in Canada. The process would also be generally representative of the PPB practices and breeding partnerships encountered in my international travels, though subject to local variations.

One feature becomes very clear from the outset. The amount of Farmers' Field activity shown by the peach colour on the right side of the chart and interspersed with the Research Station's blue is significant; it contrasts markedly with the blue and peach on the left. The left side clearly shows that the Farmers' Field only becomes active at the end of the breeding process, clearly showing the 'top-down' breeding process, noted by Vernooy, which treats farmers as 'mere recipients' (Vernooy 2003a). An additional problem with the 'top-down' approach is that the optimal conditions of a traditional research station are often at odds with the environmental realities of farmers' specific fields and conditions. In low input situations where the climate or soil conditions are less favourable, farmers need specific grain characteristics adapted to their land.

Very often, farmers have broader crop-growing concerns than the conventional focus on high yields and disease and pest resistance. Other important factors include lodging and stalk length, ease of harvest and storage, crop maturity, crop residues suitable for livestock feed, nutrition, taste, and cooking qualities. As well, differences in planting techniques and crop management, for instance, can serve as strengths based on the hands-on knowledge that farmers have of their land. On-farm seed trials provide a unique quality of feedback not possible in laboratories and optimized field trials.

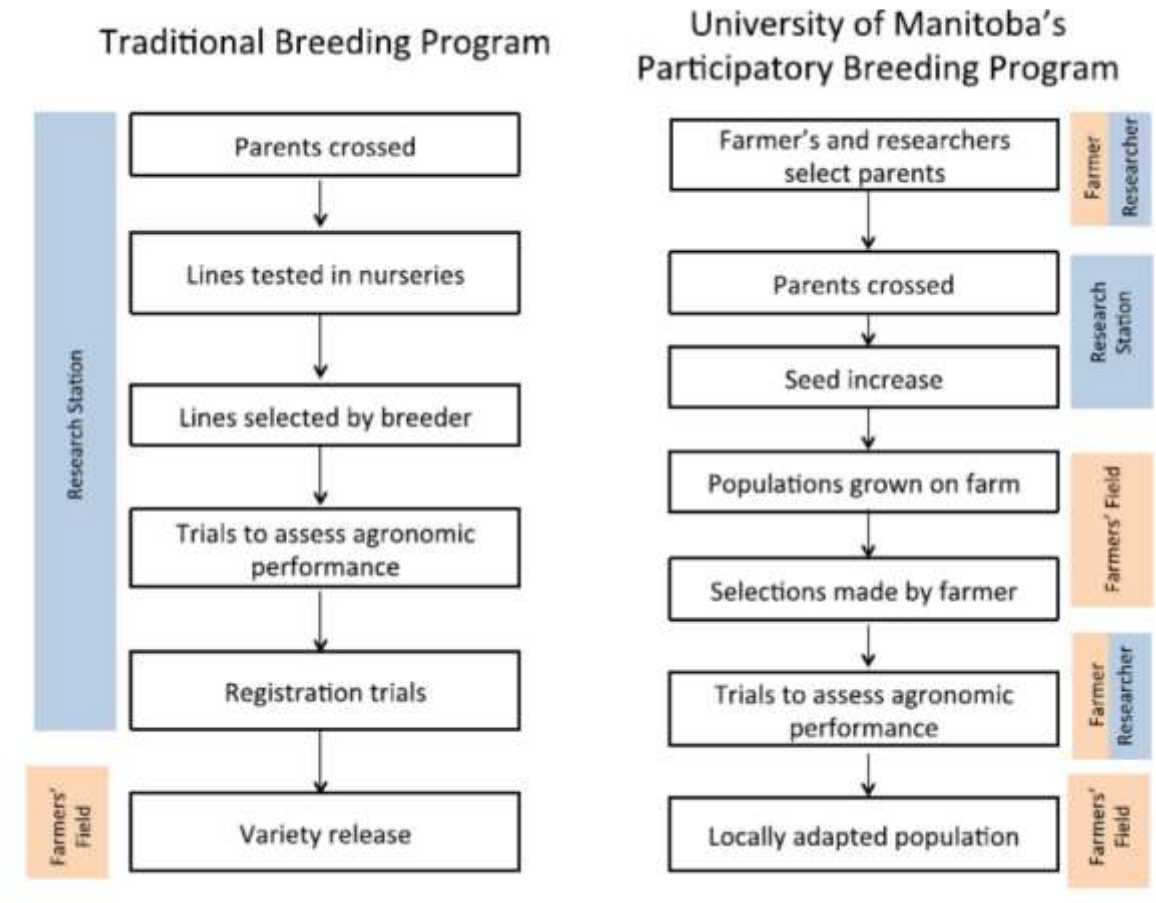

Figure 1 Traditional and participatory plant breeding. Adapted from: "Participatory plant breeding with diverse wheat populations" by N. Fradgley, 2014. Organic Research Centre, Elm Farm. 2014 Organic Producers' Conference

U of M's PPB farmers are active in the breeding selection right from the very start. After the parents (F1 generation) are crossed to produce seed, that seed is increased at the research station (F2 generation) so that at F3, or the third generation, there is enough selected seed that is returned to the farm to be grown out. Because the F3 seed has a lot of genetic variability, farmers will continue growing and selecting from the most desirable plants and seed for the next 3 years. At that point, approximately 300-500 wheat spikes are returned to U of M for further testing and for possible varietal development. Participating farmers may keep the remaining seed.

With respect to the trials to assess agronomic performance noted on the right side of Figure 1 in the 6th box, this occurs after the farmer-selected 3rd year wheat spikes are returned. U of M's research station then conducts trials that experimentally compare between the various samples sent in and compare these with other registered varieties. This research work provides some scientific PPB benchmarks able to evaluate seed and crop development.

The weight given to the farmers' evaluations of the crops and the extensive consultations between farmers and breeders is visually demonstrated in Figure 1. Whether in Canada or other parts of the PPB-oriented world, this respect for farmer knowledge and know-how is an integral part of these breeding practices.

The Natural Systems Agriculture portion of U of M's website offers a wealth of detail about PPB and its place in relation to other agricultural practices and is well worth exploring for its wide-ranging information (UManitoba, n.d.).

Dr. Martin Entz is the Professor of Cropping Systems and Natural Systems Agriculture at U of M. He and coordinator Michelle Carkner manage the wheat crosses and collaborate with oat crosses done by Dr. Jennifer Mitchell Fetch at AAFC's Brandon Research Centre and with open-pollinated potato varieties developed by Duane Falk at the University of Guelph. Dr. Mitchell Fetch is looking to identify and evaluate oat germplasm with high levels of genetically conferred disease resistance and that will have organically acceptable milling qualities in line with the farmers' needs in the ever-increasing organic market (Plant Breeding for Low Input Systems, Conference leaflet August 8, 2018).

The map shown in Figure 2 highlights the locations of the 101 farmer participants who were involved in U of M's PPB program between 2011 and 2019 trialing differing combinations of wheat, oats, and potatoes. Testing was done at 8 locations. Dr. Entz speaks of this project as a 'Canadian first' for its extensive farmer breeding involvement. As he notes, "this work provides an unprecedented opportunity to learn how farmer-selectors can contribute to genetic improvement for organic production and contributes to the development of a new breeding model for Canada" (Plant Breeding for Low Input Systems, Conference leaflet August 8, 2018).

The need for genetic improvement, in the face of 'genetic erosion' will be considered in Section 1.3 and as it turns out, the 'new Canadian breeding model' has a historical precedent from the early 1900s. Farm children got involved in PPB experimental seed selection and grow-outs over several years. Their experiments educated their farmer parents about the yield benefits of seed selection improvements based on new research emerging at that time. Though the current practices of PPB seem comparatively new to the Canadian scene, they have a long history of farmer-led seed and plant selection that is part of PPB's historical legacy over centuries, and indeed millennia (Participatory Plant Breeding summer newsletter, 2019, citing PhD thesis of Kristen Greene).

Map: Michelle Carkner

Figure 2 Location of PPB farms in green and research sites in blue, 2011 to 2019

As this map shows, the interest in PPB is Canada-wide and participant involvement has steadily grown year by year. It is the lack of sufficient and suitable seed stock that has limited the number of participants wanting to involve themselves in PPB trialing.

Foundational to participatory plant breeding programs is the need for open access to heritage seed because of its inbuilt adaptability to its growing conditions. Heritage seed has been simply defined as "any seed (grain) developed before 1955", that is, before the 1960's when industrialized agriculture aimed at improving farming efficiency, including more industrially scaled plant breeding, became common place (C-K Table 2019). Adaptability and resilience are characteristic of such heritage seed stock as the successive generations actively respond to their particular local environment. Preservation of the basic natural resource of genetic materials requires the science and the dedicated stewardship at the heart of PPB programs.

In many ways, the PPB work and vision of Dr. Entz and his associates and collaborators parallels that, for instance, of renowned plant breeder Dr. Stephen Jones of Washington State University located in the Cascadian region of the northwest US. More on Dr Jones and the Bread Lab are found at Section 2.4.ii. Dr. Entz's activities need to be seen in a larger context of international PPB research, breeding, and associated developments the world over, and not as a limited instance of PPB work in Canada.

Against the Grain Farms (AtG) vignette: To conclude this discussion of the work at U of M, my farm became involved with the PPB program in 2014 and participated in 4 yearlong grow-out selections of wheat and hull-less oats. One important lesson has been making the connection between food and the importance of seed in the food production system. I've been privileged to have Dr. Entz visit the farm several times and as a result have learned some very practical lessons. This well-respected Canadian plant breeder taught me methods for selecting wheat

and hull-less oat seed, how to identify disease in its early stages, and how to consider different varietal options for crop rotations.

As a result, my eyes were opened to the potential for PPB on our farm and across the eastern Ontario region. As a farmer, it was empowering to know that my knowledge of our land and crops was important and valued. Because the PPB program will not look the same everywhere, that very diversity is its strength. The needs of the prairie grain farmer will differ from those of the eastern Ontario grain farmer and respect for their diverse needs and their particular 'target environments' are actively supported by PPB.

I have used the knowledge gained from working with PPB and Dr. Entz to trial and select a number of heritage grains that I currently market at AtG for my niche wholesale and retail markets. The lessons learned in earlier stages provide a sound foundation for my own continuing seed selection, trials, and production.

1.3 The Bauta Family Initiative on Canadian Seed Security and Other Seed Organizations

Simply put: without seed we have no food. Launched as a national program in 2013, the Bauta Family Initiative on Canadian Seed Security aims, according to its homepage, at "building a movement for resilient seed systems across Canada" (BFICSS, n.d.). To fulfill this mandate, it works to support Canadian farmers to increase the ecological quality, quantity, and diversity of seed that is produced and regionally adapted. The diversity component recognizes that successful food production will increasingly depend on seed's inbuilt adaptability to its target environments. Given the uncertainties inherent in climate change, developing seed diversity in many local areas is an essential component of Canadian food sovereignty and security. Why? Without diversity, our food systems are fragile and vulnerable for being built on shrinking gene pools. In face of climate forces, adaptable seed needs a genetic base as large as possible. (BFICSS, n.d.)

BFICSS's aims and purposes arise in the face of the concerted "genetic erosion" mentioned earlier: in the last 100 years, over 75% of the genetic diversity in crops has been lost (FAO 2004). Added to that, food system vulnerability is increasing because 75% of the world's food systems are now dependent on just 12 plants and 5 animal species, compared to the 2500 plant species once domesticated by humans (ibid, Box 5).

This loss of genetic diversity also features in the corporate consolidation in the privately controlled seed industry. As of 2018, 4 firms control 60% of global proprietary seed sales (Phil Howard 2018). The loss of already developed seed lines residing in many pre-merger seed companies is indeed a loss on many fronts. Given factors like genetic uniformity, high yield, high maintenance, high inputs, and high costs that characterize privately bred seed stocks, it is entirely appropriate that BFICSS works to conserve and increase as much of the available genetic biodiversity as is possible. My experience is that this field-oriented organization is representative of the many others who well understand that seed resilience is essential to coping with climate change because it preserves and expands the range of genetic resources.

To this end, BFICSS's science grounding has been instrumental in developing some applied research programs, focused on organic and agroecological seed conservation and development goals. One of these pioneering research initiatives has already been covered by the PPB work at the University of Manitoba, as detailed above in its 4-year national PPB program.

A second research program initiated by BFICSS will be led by Seed Change (formerly USC – Canada). Based on PPB lessons and models learned from its extensive international PPB and seed conservation support work since 1945, SeedChange is now partnering with the Centre for Sustainable Food Systems at the University of British Columbia (UBC) on a new Canada-wide project for vegetable improvement using PPB methods (UBC farm & Bauta family, n.d.).

Under the leadership of post-doc student, Alexandra Lyon, and Professor Hannah Wittman, a new 5-year research project called Canadian Organic Vegetable Improvement (CANOVI) has been established. Some additional funding is being provided by the Agriculture and Agri-Food Canada Partnerships. CANOVI will focus on breeding peppers and carrots. Because most carrot seed comes from California, Lyon and Wittman will begin making crosses between existing commercial carrot varieties and experimental lines. With the help of local farmers, they will select for new varieties that have flavour and nutrient potential and most crucially, are adapted for the Canadian climate. For more detailed information on CANOVI, see the UBC site (Land UBC, n.d.).

Though more detail about the extensive work of SeedChange cannot be covered in this report, I heartily encourage readers to explore its new website and in particular, view the 2 minute video by Bruce Cockburn, explaining its work for farmers and for seed and the reason for the name change (Seed Change, n.d.). Bruce has supported this visionary work for about 50 years so it's informative to see SeedChange through his eyes. As a Canadian organization working first in various international projects using PPB methods for sustainable agroecology, its intensive

field experience is a working model with applications for seeding change in food systems everywhere, including a number of Canadian projects.

As a program of SeedChange, BFICSS is specifically dedicated to actions that address Canadian seed security and the food systems upon which it is dependent. As well, BFICSS partners together with Seeds of Diversity, a grass-roots seed saver organization seeking to protect Canada's seed biodiversity (Seeds of Diversity, n.d.). To this end, one of their activities is developing community seed libraries and a Canadian Seed Library for heritage/ rare and locally adapted seed varieties. Another goal is education about protecting pollinators and ensuring the wide range of insects and animals essential to crop fertilization. The alarming biodiversity loss of these creatures is often due to the widespread use of pesticides, coupled with eroded natural habitats no longer available to sustain their life cycles (Seeds of diversity – pollinators, n.d.).

As a compact example of seed-oriented collaborations, BFICSS, SeedChange, and Seeds of Diversity exemplify some of the concerted efforts to actively respond to the problem of genetic erosion as it applies in Canada. Seed-saving has been a primary farmer activity for thousands of years, and this genetic heritage is the basis of new varieties. This point is the foundational basis of PPB and its active relationship with open source seed. As has already been stated, seed's genetic biodiversity carries the inbuilt capacity for climate resilience and adaptability. For the sake of our climate-vulnerable food systems, the living heritage carried in seed needs to be cherished, protected, and carried forward as a human birthright.

The National Farmers Union (NFU) has highlighted this serious problem by organizing its "SOS! SAVE OUR SEED" campaign. Their handbill states that a seed group lobby is forwarding "the idea that plant breeding must be financed by charging farmers royalties on farm saved seed or the farmer's entire crop" (Save Our Seed 2019). Among many other concerns, the handbill notes: "farmers have been saving their own seed for thousands of years, and these genetics are the basis of new varieties" (ibid, 2019). This exact point is the foundational basis of PPB and its active relationship with open source seed.

In summary, in my opinion, a seed's genetic biodiversity carries the inbuilt capacity for climate resilience and adaptability. How foolish and short-sighted, and indeed dangerous it would be to squander this precious legacy. For the sake of our already vulnerable food systems, the living heritage carried in seed needs to be protected as a human birthright.

1.4 PPB in Larger Contexts

Of the many contexts that could frame PPB as presented herein, the next three subsections will provide some larger reference points. They situate the viability and impact of PPB and its contributions in relation to other factors like climate change, agroecology, and Canada's new National Food Policy.

1.4.i Climate Change

Intensification of many environmental conditions features large in Canadian climate change forecasts. Canada's three coastal oceans have already warmed significantly, and the results of less oxygen and more acid in them will increase greenhouse gas releases. While increased warmth may allow longer growing seasons, that benefit will be offset by other problems like excess rainfall in spring, autumn, less snow in winter, and reduced water supplies in summer. Floods and droughts are already becoming commonplace. Increases in temperature will impact all ecosystems and will increase the risk of wild fires (CCCR 2019). The Fort McMurray fire and evacuation of 88,000 people in 2016 is but one example of the enormous land devastation and damage costs predicted to increase (Changing climate 2019).

Because farming is so weather-dependent, it is particularly vulnerable to the impacts of climate change: its annual success requires the right amounts of rain and heat at the right times of year. Once-reliable planting dates have become nonsense as unseasonal rain, flooding, heat, cold and drought conditions – often within the same year – disrupt generations of locally predictable weather patterns. The consistent seasonal patterns needed to bring food to market can no longer be taken for granted. Pest and disease management are climate-influenced, as is livestock care. The Climate Atlas shows that areas of increased heat will likely include important food-producing regions like the Okanagan Valley, the Prairies, southern Ontario, and the Maritimes (Climate Atlas 2019).

A poignant example of unseasonable conditions is the unprecedented snowstorm that hit southern Manitoba on October 11, 2019, after a very dry spring and summer and unusually wet autumn. These already abnormal and unpredictable conditions have meant that only 14 % of the province's 1.4 million acre soybean crop had been harvested before the storm set in. Potatoes are a valuable crop that are also taking a weather beating with only 60% of the crop harvested by snow time (Kives 2019).

With such unprecedented conditions in mind, adaptation to and mitigation of climate change become prominent concerns. Six major classes of agricultural adaptation are identified by Food and Agriculture Organization (FOA) of the United Nations (Climate Atlas 2019; FOA 2007):

- seasonal changes and sowing dates
- different varieties or species
- water supply and irrigation systems
- inputs (fertilizer, tillage methods, grain drying, other field operations)
- new crop varieties
- fire risk management

Farmer and farm resilience will mean taking adaptive measures like experimental planting of new produce varieties, over-planting to deal with losses, and breeding locally adapted plants. Growing a biodiverse range of crops lessens the impact of monocrop failure because it provides income alternatives (Climate Atlas, n.d.). The Manitoba example of large acreages of soybeans and potatoes still in the ground underlines the food chain impact on farmers and on consumers too.

For society at large, as well as for agriculture, leadership actions to mitigate climate severity are possible, given that the latter contributes 10% of Canada's greenhouse gas emissions (Agriculture Canada, n.d.). The release of nitrous oxide, produced when nitrogen fertilizers are applied to the fields, is actually 300 times as powerful a greenhouse gas as carbon dioxide (BBC UK, n.d.). These inputs, as well as the emerging health problems associated with the agricultural inputs of glyphosate, the main ingredient in the herbicide Roundup© require leadership and mitigating action on their respective fronts (Samsel 2013; EWG 2019). The reason is that the health of people mirrors the health of the planet and vice versa.

Given that Canadian temperatures are rising at twice the global rate, Canadian farmers already know the impact of this reality on all aspects of agricultural business and all stages of food production (Environment Canada, n.d.). Weather uncertainties mean farming uncertainties. Adaptation is not solely about seed responsiveness to its conditions, mitigation also requires the application of environmentally responsible farming practices (Northbridge, n.d.) Because our food systems are so very dependent on farming and are equally vulnerable to climate change, food sustainability and security are major concerns at every level of Canadian society.

1.4.ii Agroecology

Agroecology is a cutting edge discipline that integrates ecological methods of environmental sustainability with agricultural practices, by treating agriculture as a biodiverse ecosystem. (HLPE 14 full 2019). Understanding the agroecological features that underlie the resilience of traditional agroecosystems is an urgent matter, as they can serve as the foundation for the design of adapted agricultural systems. Observations of agricultural performance after extreme climatic events (hurricanes and droughts) in the last two decades have revealed that resiliency to climate disasters is closely linked to farms with increased levels of biodiversity.
While first coming to notice as normal farming practices in developing countries, its relevance and practices are on the rise in industrialized countries as well. For a thorough overview of agroecology in Canada, see Isaac et al, (Isaac 2018). The local emphasis carries the potential for innovative PPB farmers and their associated seed to table partners to be able to develop the niche markets which sustain local communities and their economies.

Agroecology is considered to be a transdisciplinary field that puts emphasis on three areas: the principles and practices of science; ecological practices and agricultural management; and social movements – all of which are concerned with sustainable food production. Agroecology is a cohesive integration of these three areas, and there is an emerging consensus which supports their respective contributions to sustainable food production (FAO 2016; HLPE 2019; Ruth 2017). These areas are important in relation to overall adaptability because it is people power that will transform the food systems hit by the realities of climate change. Food sovereignty and security are powerful motivators for change.

Certain characteristics help to describe agroecological research and learning because its knowledge base involves a shift to decentralized, horizontal, bottom up and participatory processes. Because this shift is based on seed adapted to its target environments, practical support is needed for farmers and their federations and for the many other organizations with on-farm knowledge and experience to share. Such important bodies of knowledge have essential information to contribute to the more formalized systems of research and study.

Sustainability at all levels is a key concept built into agroecology. Particular ecosystems require particular treatments in order to function sustainably. Given the challenges of climate change, sustainable and resilient ecological practices provide viable responses. In my opinion, healthy farming practices nurture their locales as well as providing nutrient-rich foods and economic viability.

Some key areas of agroecological practice include active support for agrobiodiversity resilience, natural soil enhancements, low-input practices, locally adapted seed stock, pollination and biocontrol of insect pests and diseases, carbon capture in soil, cover crops and mulching – all activities that help maintain healthy ecological balance. These practices also tie in with the previous section about climate change adaptability.

An important study shows that agroecology is both viable and scalable in many contexts. Because small-scale farmers produce most of our food, these farmers could well double food production in the years ahead simply by adopting agroecological methods (Altieri et al 2012). The notion of scalability is one I encountered during my travels. Several examples from the Canadian scene help set agroecology in an expandable context related to my travels.

Trevor Heide is one notable speaker presenting at a forthcoming Saskatchewan workshop entitled Soil Health and Regenerative Organic Agriculture. His topic is "Organic Practices on a Large Scale". He and his team are preparing to transition their 40,000 + acres to certified organic in 2020. Centred in research and innovation and community opportunities, this commitment to sustainable farming practices is significant (Saskorganics 2019).

With 1,500 acres of acreage, Loïc Dewavrin works on his organic farm located west of Montreal. Because of his concerns for food security, he actively saves his own seed so that "generations of crops and seeds … get acquainted with his land" (Dewavrin 2019). Being one of the 10 largest organic farms in eastern Canada means that the volume grown on his farm provides an income for 4 families and food market sustainability.

With respect to the assessment of agroecology in Canada, Isaac et al notes that while it is a growing movement and its principles and practices are gaining traction, it presently remains "on the fringes of Canadian policy at the government level" (Isaac et al 2018). In light of the "broad enthusiasm for agroecology among Canadian agricultural producers, farmers' organizations, and other food systems actors", building broadly-based alliances among the various stakeholders is suggested as one means to generate the people-pressure needed to effect needed food system changes (ibid, 2018).

1.4.iii Canada's New Food Policy

"Everyone at the Table", Canada's first-ever Food Policy, was launched in June 2019, after extensive consultations with a wide range of interested parties. The one feature to be

highlighted here is the budgeted $50 million for a Local Food Infrastructure Fund, to be made available over 5 years. The Fund has 2 streams (Canada 2019):

- *Infrastructure and Equipment Improvement Projects* – these local infrastructure initiatives will include equipment, community gardens, greenhouses and kitchens, programs at food banks and farmers' markets. Non-repayable funding up to $25,000 is available.
- *Projects to Strengthen Local Food Systems* – targets various communities, groups, and organizations whose goals aim to reduce food insecurity sustainably by strengthening or establishing a local food systems. Non-repayable amounts up to $250,000 are available for capital and food equipment.

Because this new policy focuses on increasing domestic and local food production, it aims at better access to healthy food and the reduction of food waste and food insecurity (Nudds 2019). The policy is important for the emphasis on the food security provided by *local* food systems and because these partnerships also sustain *local* economies. This *local* emphasis carries the potential for innovative PPB farmers and its associated seed to table partners to be able to develop the niche markets which sustain local communities and their economies.

Additionally, the 2019 Canadian Senate report "Made in Canada: Growing Canada's value-added food sector…" recommends innovation support in the food and beverage sector (Senate 2019). It recognizes that 'added value' is currently underserved in that sector, as compared with the Netherlands for instance, and so is an area rich in potential opportunities (ibid, 2019). Because a number of food and beverage producers are eager for my PPB heritage grains, I can attest to the 'value-added' practices noted in the Senate report for the impact they make in the seed to table network.

Canada's "first-ever" National Food Policy gives emphasis to local food initiatives and infrastructures, and therefore invites PPB practitioners and their respective partners to contribute to sustainable Canadian food systems. Such a government policy gives value-added credibility to PPB and its food community partners.

As well as its national and regional emphasis, Canada's new Food Policy links to food policy developments at the United Nations, with the latter's endorsement of agroecology (HLPE 2016; HLPE full 2019). Thus, Canada's new domestic and locally grown food security efforts can be located as a part of international food security initiatives. In such a global context, active support for PPB initiatives, research and agroecological practices are timely for their ability to contribute to food security.

2 PROBING PPB VIABILITY 1: COUNTRIES

2.1 Nicaragua

Through my contact with "SeedChange" and their twelve-country Seeds of Survival (SoS) program, Nicaragua was the first country I visited as a Nuffield scholar. The SoS program aims to support farmers dealing with erratic climate change and the widespread effects of repeated droughts, especially the devastating one of 2015/16. With practical support in mind, SoS is piloting projects which foster local agricultural research committees. In fact, local partners are always the key implementers of SeedChange's programs, a distinctive feature that empowers local farmers to develop local seed in their local conditions.

Faced with challenges like changing weather patterns, poor soil, difficult farming terrain, and inadequate water, farming communities are learning to breed and grow a greater diversity of foods suited to their shifting conditions. Starting community seed banks allow these farmers to conserve valuable landrace varieties of plants. This includes breeding developed from available seed stock – seed that's needed to promote biodiversity. Opportunities for exchanging climate-adaptable seed from seed banks in other regions and countries provide specific resources to improve and enhance the seed development of local crops. Empowering rural youth and women are parts of SoS's strategies, as well as encouraging local micro-businesses. For a success snapshot, see Nicaragua (Nicaragua 2019).

Farmers are being trained to develop drought-resistance for early harvesting maize and nutritious sorghum varieties. I had become interested in their coloured sorghums and we were able to view these field trials at three farms in the vicinity. Seeing SeedChange's work in person gave context and specific substance to their mission aims. Their very practical farmer training and research work is important for ensuring a basic food supply and sustainable food security. Open source seed security is considered to be a fundamental human right by SeedChange, as one of many groups upholding this principle with practical applications. To reiterate a point made in Section 1, having biodiverse seeds adapted to local conditions is essential to survival.

Our visit included time at a small, grassroots NGO where a Canadian farmer was helping the local farmers to grow out and scale up their pinto bean production, help them form a co-operative, and then help them to sell the pintos by export to the Canadian market. Learning from the local farmers as well as teaching them created vital interactive information-sharing that was not just a top down seed sales approach. By helping farmers to grow a regionally adapted crop, I was impressed that the NGO was working to help them with niche market opportunities that would bring premium pricing.

Because of the civil unrest in Nicaragua during the 18 months since my visit, I must admit to feeling some heart-break because of the way that investment going into and out of the country has seized up. Many of the shareholder farmers were selling into restaurants, the tourism industry, and some had formed export co-ops for their products. All this has soured, at least for the present time. The unrest has also led to many males fleeing the country for fear of prosecution.

Nicaraguan farmers have shown great resilience and initiative after many were forced off of the fertile lowlands and into the highlands, an area with a climate change-induced dry corridor. As the local communities face harsh, prolonged droughts, SeedChange has been helping the farmers use PPB methods to sustainably improve their food security and income and marketing co-ops.

One important lesson from this first Nuffield visit was that it helped me to see the PPB-related potentials for marginal land development. The resilience and adaptability of the people themselves was a lesson in perseverance under pressure. This example links with the resilience and adaptability potential of Canadian farmers as we face our particular climate challenges. These lessons directly connect to the two key issues of this report: PPB as a viable response to climate change and the impact of PPB on heritage grain networks.

2.2 The Republic of Georgia

Regarded as a “biodiversity hotspot”, Georgia straddles the line between Europe and Asia situated at the eastern end of the Black Sea in the Caucasus Mountains. I was invited to go there to learn more about the PPB of their ancient wheats by Lali Meskhi, Chairperson of the Georgian Wheat Growers Association (GWGA), after we met at the Bologna food conference. She hosted my husband and I, and acted as our interpreter, so all our visits were full of Georgian cultural history as well as agricultural information.

In times past, fourteen of twenty of the world’s known wheat varieties were grown in Georgia, including five which were endemic (Jorjadze 2014). Because these old varieties have a long, indeed an ancient, history of adaptability, I was very intrigued by the number of international plant breeders travelling there to source seed stock. It’s a harsh land with harsh conditions; it’s mountainous, and with different climatic regions. This means that its many landrace wheat varieties have been subjected to many climatic and genetic variations over the centuries and therefore are greatly prized for their genetic diversity. The proven adaptability of such seed stock brings the hope that new strains developed from it will be able to survive global warming.

Lali Meskhi sums up the importance of wheat: “Wheat it is more than an ordinary grain, it symbolizes life, fertility and welfare, it played a major role in the life of Georgians from ancient times, associated with daily bread, food security, moral values and civic responsibilities. The bread wheat domesticated 8000 years ago is still grown here, still used for food, rituals, medical care” (Meskhi 2019).

Respect for wheat’s meaning is reflected in her work as chairperson of the GWGA. In 2018, Meskhi was instrumental in initiating a complex process to register the Georgian Wheat Culture (endemic species and land-races) as Georgia's intangible cultural heritage. Having formed a working group of experts, breeders, researchers, farmers and bakers who did extensive preparatory work, the Georgian government granted a National Status to the Wheat Culture in Georgia on 25 March 2019. In turn, this approval allowed Meskhi’s group to make a submission on 29 March 2019 for a UNESCO nomination 'Intangible Cultural Heritage for Urgent Safeguarding' (ibid, 2019). Summing up her work for wheat conservation and commercialization, the goal aims to bring back healthy bread to their tables.

I first met Georgian plant breeder Mariam Jorjadze at the Bologna conference and then again during my Georgia visit. She is associated with the Biological Farming Association Elkana, Tbilisi, which is working on the restoration of Georgian seed bank stock. They are developing a systematic wheat inventory so they can plan and develop the conservation of this national heritage, one deeply embedded in their language, culture, traditions, literature, and eating habits. Georgian soft wheat (*Triticum aestivum*) and other cereals were found dating back to the Neolithic Age, showing just how ancient some of their grains are. Because some of these landraces are critically endangered, the inventory produced by Jorjadze and her colleagues traces the history and characteristics of as many varieties as possible. Their example shows the importance of seed banks, both within Georgia and in other countries where their seed is preserved (Jorjadze 2013).

During this trip, I also went to approximately six farms with plot trials for heritage grain from original varietals. One farm in Lomtagora has a centre for plant protection. Another visit was very instructive because of the farmer’s business savvy. Due to the difficult political climate after communist Russia withdrew in the early 1990’s, the lack of seed stock turned into a business opportunity for a large scale farmer. He hired his own plant breeder to work on his farm – maybe a couple of thousand acres – using PPB methods. Since that work started, he has gone on to register a numbers of new varieties that they trialed based on old wheat and maize seed stock.

We spent the day at this farm while they were harvesting selected PPB seed they'd established. This farmer has grown viable seed stock on a scale large enough to sell to other farmers. He is a significant example of a scaled up niche market with a valued product to sell, as well as a valuable service for other farmers. His business left a deep impression on me because this PPB example of scaled up production could be applied to Canadian farmers with similar innovative aspirations.

2.3 Estonia

I was invited by Estonian plant breeder Kulli Annamaa of the Estonia Crop Research Institute to visit her country, while we were both attending the Nordic Heritage Grain Conference in Denmark. Her conference presentation talked about re-establishing the old varieties of rye, due to its regenerative nature that can be grown on poor soils, can adapt to weather extremes, requires little input, and that it is one of the highest nutritional grains. (Estonia Crop Research, n.d.)

The Estonian Crop Research Institute, known formerly as the Jõgeva Plant Breeding Institute, is a result of a 2013 reorganization now under the governance of the Estonian Ministry of Agriculture. Its overall mandate seeks to maintain agro diversity by employing a wide range of activities including breeding new varieties of crops, maintenance breeding of existing crops, preserving plant genetic resources, producing and distributing certified seed. The work also involves active national and international cooperation with R&D institutes and universities to increase the scientific levels of research. As well as contributing scientific expertise, it helps to develop agriculturally-oriented legislation. The Institute also promotes the close collaborations with farmers and industry as a prerequisite for the practical implementation of research results. This latter point truly emphasizes the contributory role of farmers in breeding practices and results, and so underlines the viability of PPB in Estonian research. (EuroLegume, n.d.)

As one plant breeder to another, Kulli shared a story about an earlier Estonian plant breeder, Rene Berg, who immigrated to Canada after World War II. This story shows that rye's ancient and lengthy genetic heritage became available in Canada and contributed to crop development here.

Rene Berg's grandfather, Count Friedrich Berg had developed Sangaste rye in 1875, with modifications by himself and other breeders over the subsequent years. Once in Canada, Rene Berg worked many years at the University of Alberta in Edmonton, having obtained Sangaste seed for trialing in 1951, and then licensing it in 1957. In 1971 he developed a new variety

named ‘Kodiak’ that was better adapted to Canadian conditions and grown widely until the 1990’s. Kodiak was also tested in field trials at the Jõgeva Plant Breeding Institute, as it was then known (Ryeroute b. 2012).

One of the great granddaughters lives here in Ontario and is most interested in having this widely celebrated rye grown here. To add to the Estonia-Canada link, in late August 2019, Kulli sent me some Estonian rye from her Institute’s seedbank that I will plant in the autumn. To cap this off, I have been able to track down and buy some Sangaste rye from an old time farmer who has been growing small amounts for a few bakers in western Ontario.

Estonia, like Georgia, became independent of the Russian communist regime in 1991, and that resurgence of national identity, culture, and tradition finds its place in its agricultural heritage as well. Rye, with a crop production history of well over one thousand years, was a long-time staple in the Estonian diet and embedded in its way of life, until consumer demand for white bread changed that for a time. Now, along with the resurgence of Estonian identity, rye re-education and regeneration are at the forefront. Taken together with an eye to responding to changing weather patterns, and with the implementation of sustainable and environmentally friendly agricultural practices, Estonian rye breeding is strongly associated with PPB methods. This revival involves terroir identities and network partners in the whole culture associated with rye food and beverage products in all their forms (Ryeroute a. 2012). The search for and application of ‘added value’ as previously mentioned in the Canadian Senate’s Report, “Made in Canada”, parallels Estonia’s similar goals. Rye, though considered a minor cereal crop, has a longstanding history of adaptability and high nutrition content.

What’s important about this Estonian story is that it shows PPB’s viability and impact, not only in its own country but as some of rye’s genetic heritage now a part of Canada’s rye heritage. Given the loss of biodiversity that is being lamented, this instance of a small quantity of the original Sangaste rye seed still available gives potential to widen the gene pool.

One further Estonian development is noteworthy. In early 2019, the Estonian Research Group formed a collaboration between the Agriculture Research Centre, the University of Life Sciences, and the Estonian Crop Research Institute. The program aims to create a central electronic system to link and integrate existing data with analytical models and practical applications. This will help to create an added economic value to agricultural data and support the further development of precision associated with agroecological farming. As well, it will help to collate farmers’ findings from on-farm trials of different varieties adapted to climate change.

This collaboration also promotes the testing of heritage grains for their added nutritional values and with applications into niche markets. I see this collaboration as a model that could be replicated in Canada between research stations, universities, and other data collection from PPB trials across the country.

2.4 United States of America

2.4.i Dr. Bob Quinn – Kamut

Bob Quinn has been instrumental in re-establishing a heritage wheat (Khorasan) that is now branded under the name of Kamut, which has been grown commercially for many years now and ships internationally (Quinn, n.d.). Starting with just 36 kernels, he researched and grew out the seed for many years before beginning to form alliances with other farmers for contract growing. Bob's outstanding contributions to growing heritage grains and his PPB practices are an amazing example of successful innovation from seed to table. After years of modern farming methods, he transitioned his 2,400 acre Montana farm in 1986 to being fully organic. This is another example of scaled up farming operations. Bob Quinn started with a small amount of seed and by growing out, saving seed, creating seed stock that was regionally adaptable and resilient to his growing conditions and by developing a market for a unique grain, Quinn has shown Canadian farmers that this can be a viable and economical model.

Quinn was present at the Wheat Landraces conference in Bologna, in part because his company organized the event. Though I've known of his ground-breaking work for quite a while, I met him in Bologna and then again at a California conference not covered in this report. In addition, I've had internet conversations with him about seed swapping, rare seeds and variety trials.

At the forefront of many agroecological projects, Quinn's wide-ranging contributions include living out the Hippocratic conviction that 'food is medicine and medicine is food'. A quick look at his website bears out this concern with the series of pointed and well-researched articles he's written on the theme of the high cost of cheap food (Quinn, High Cost, n.d.). Regenerative agricultural is one of his prime goals and coupled with that are alliances he's built with various universities and research teams to scientifically establish the health advantages of heritage grain varieties. With its higher protein content, delicious taste and notable cooking qualities, Kamut is a case in point.

Quinn is taking this grain research beyond flavour and appearance factors and into functional food applications. It's the same idea I work towards with the beta glucan barley and other Against the Grain products I produce. By functional food, I mean that it's good for the soil, good for the farmer, and good for the consumer.

The farming model that Quinn has put into place provides an example for Canadian farmers with the same kinds of shared environmental and health concerns. The impact of his methods and the viability and scale of Kamut on the international scene are clearly evident. His on-farm work and his educational investments bear witness to what is truly possible and thus set the stage for similar Canadian enterprises.

2.4.ii Dr. Stephen Jones – The Bread Lab

"Locally grown grains are the missing component in many regional food systems" (Rocky Mountain Seeds, n.d.). This gap identified by Steve Jones of Washington State University is one that I feel is also missing in Canada's regional food scenes. As one of the top wheat breeders in the world, Dr. Jones feels that plant varieties specifically adapted to regional production and end-use are important components in building resilient food systems.

Through the extensive work at the Bread Lab, the unique research facility Jones initiated, he and his team have established PPB as a viable model for successfully paralleling the more centralized breeding programs for modern cereal crops (Bread Lab, Murphy et al 2004; West 2017). The Bread Lab's homepage has a series of rotating photos to show the research facility and its surrounding fields that convey the range of its scientific work. Along with its many and varied collaborators, the Lab has researched and developed PPB methods in ways that have helped many farmers step away from the commodity market with its dictated prices. The Bread Lab has set up and developed PPB for area grain farmers where they can grow a crop that is adapted to their land (good for the farmer) and has helped them develop markets with area manufacturers like bakers, brewers, manufacturers. The farmer now has a crop that he can grow in an environmentally sustainable manner and has a market for this crop, so he will get paid for his efforts. The end user (whether a baker, maltster or brewer) is interested and willing to pay because it is unique, it offers value added, it offers them an edge on competition in its uniqueness. They become invested in seeing the crop grow, mature and harvested.

The regional farmers are invested in the PPB work because it gives them some control over their crops' value; as well, end users, whether professional food producers or consumers are

able to understand and support local and sustainable food systems. It's the PPB focus that allows for these kinds of interactions around common goals.

With farmers and breeders working together to form collaborations with chefs, bakers, food producers, brewers, maltsters, distillers, and consumers, they have been able to scientifically develop seed supplies for crops that can be viably grown in their Cascadian region in the northwest United States. These collaborators participate in the risks that farmers incur to grow the specialty grains needed for their end products.

Dr. Jones believes that PPB creates resilient food systems through regionally adapted seed stock (Bread Lab – Local Food Systems, n.d.). Such stock is important economically as well as socially and culturally. According to Jones and his many associates, the impact of his teams' work in many community partnerships over the years has thoroughly revived the Cascadian economy. The area with its PPB focus on grains and other crops has become a primary model for other types of seed to table partnerships. Interestingly, a locally oriented grain revival in the northeastern United States is in process (Wbur 2019).

The lessons and models developed through the Bread Lab have been extended to three-state PPB-related collaborations with plant breeders, pathologists, and extension personnel at Washing State University, the University of Idaho, and Oregon State University. They have put together a series of regional demonstration projects, plots for seed production, disease nurseries, and developed programs for breeding quality traits in seed production as grown on-farm in seed production areas of these 3 states. The involvement of cooperating growers is essential at all PPB levels and stages in choosing the seed, the traits, and the field design for the evaluation plots.

Andrew Ross, a plant breeder in the Department of Crop and Soil Science at Oregon State University is a founding member of the Bread Lab Collective. Two of his very detailed research papers provide insights into the scientific work that the Bread Lab has initiated and modelled. One paper is entitled "Flour Quality and Artisan Bread" (Ross 2018) and the other is "A Shifting Climate for Grains and Flour" (Ross 2019). As an experienced plant breeder, he brings a scientific nuance to the viability of PPB and its impact on seed to table partnerships.

AtG vignette: I became intrigued and especially interested in the participatory farmer-breeder-chef collaborations in western Washington that Jones has developed. The Grain Gathering, a yearly event hosted by The Bread Lab, has become a sold-out event with around the world attendance by plant breeders, farmers, millers, bakers, distillers, brewers, food historians, and anyone interested in safe, healthy food. With topnotch speakers covering every topic in seed to

table collaborations, I came away hopeful, excited and encouraged that the model of PPB being demonstrated there could also be replicated in Eastern Ontario. By seeing the fields of PPB crops growing in the Cascadian area and on those farms, I began to understand the fulsome potential of PPB in scalable heritage grain production.

A brief list of lessons associated with the Bread Lab helps to pinpoint some features that can provide a framework for similar applications in Eastern Ontario.

- scientifically oriented facility with plant research labs, an extensive industrial test kitchen, well-equipped meeting rooms and offices
- full commitment to PPB trials and seed and crop development
- education programs for farmers, for collaborating partners, for professional and public interest groups, including consumers
- market strategy development
- diverse and actively invested partnerships

Modelled on the Bread Lab, such an Eastern Ontario facility would provide an active support centre for continuing PPB research and its applications able to contribute to healthy food systems.

2.4.iii Rocky Mountain Seed Alliance

While attending “The Grain Gathering” I had learned of another regional grain program, The Rocky Mountain Heritage Grain Trials Project. In early 2016, Rocky Mountain Seed Alliance (RMSA) held a Grain School course at the University of Colorado, Colorado Springs (UCCS). This course gave rise to a new collaboration of grain farmers, breeders, and researchers. The Arkansas Watershed Grain Project, as the group came to be called, first set out to identify ancient and heritage grain varieties that would perform well in their area, and then to increase quantities of the best performing varieties for use by local farmers. Their aim was to build the necessary seed stocks and so lay the groundwork for a new local grain economy to emerge (Rocky Mountain Seeds Story, n.d.).

The Rocky Mountain Seed Alliance partnered with the Arkansas Watershed collaborative and UCCS to expand this project across the entire Rocky Mountain region. The initiative closely aligned with RMSA's mission to strengthen seed diversity in Rocky Mountain communities through local networks of seed stewards. Returning heritage grains to active use in a network of growers, processors, and consumers is a powerful way to ensure that this diversity lives on.

It also becomes a boon and source of pride for a region's culinary culture, with local restaurants and artisans creating delicious breads, beers, and pasta from their own heritage varieties.

Once again, I was encouraged and excited about the potential for Eastern Ontario as a local grain economy. Through the Rocky Mountain project efforts, I saw an important model to help mitigate the risk to farmers of variable weather patterns. The farmers' work to identify and collect the regionally adaptable seeds of grain varieties - varieties that had low-input, drought-tolerant, deep-root, tall-straw grains – was deeply allied to PPB processes in ways responsive to their unpredictable climate conditions.

As mentioned in Section 1.3 on the Bauta Family Initiative on Canadian Seed Security and including its valuable partnerships with SeedChange and Seeds of Diversity, these homegrown groups are representative of Canadian seed saving and producing activities already in operation. The Rocky Mountain Seed Alliance and the Arkansas Watershed Collaborative provide a resource model of similar-minded seed stewardship organizations who are dedicated to preserving and furthering genetic seed diversity, for reasons already discussed. More remains to be done in Canada, as elsewhere, to strengthen and carry forward our longstanding seed legacy. Funding commitments from various stakeholders will play their part in providing the means to support this important work.

2.4.iv The Land Institute – Kernza Perennial Wheat

Continued travels and contacts led me to the Land Institute and their interest in plant breeding for perennial grain and seed crops (Land Institute, n.d.). The Institute's vision and mission statements include their demonstrated "scientific feasibility of our proposal for a natural systems agriculture" (Land Institute Vision, n.d.). This latter phrase recalls the PPB work in Natural Systems Agriculture done by Dr. Entz at the University of Manitoba, mentioned in the first chapter. Although unable to travel to Kansas to visit their facility, I have participated in many webinars covering their work in PPB. One such webinar specifically focused on relationships between pollinators, natural enemy species and cereal crops. Their ongoing work to identify grain species that produce their own fungi that increases nutrient uptake and improve plant health is fascinating. Such research ties in with the above-mentioned vision of a Canadian or Eastern Ontario scientific facility adapted to our own regional conditions and needs.

Unexpectedly, one result of my association with the Land Institute expanded my understanding of the potential of PPB - no longer did I see PPB as only about flavour and bread/cooking

potential but also about crop resilience and inbuilt pest resistance potential. As a caterer, chef and baker myself, I care about the flavour, cooking potential, and nutritional benefits of grains. Those concerns were raised to a new level by expanding my understanding that PPB selections could also involve inbuilt pest resistance, or use PPB for the selection of crops suitable for green cover crops.

In fact, with soil health in mind, Against the Grain Farms has been involved with the Farmer-led Research Program Trials for 2019, being one of 19 assorted trials sponsored by the Ecological Farmers' Association of Ontario (EFAO, n.d.). Using the natural mineralizing properties of basalt rock dust that complies with organic certification standards, yield comparisons of Heritage Amber Spring Wheat were grown in trial plots with and without basalt. Thus far, a visual evaluation of the test plots seems to indicate the fertilizing capacity of the basalt, with more testing to be done.

Because The Land Institute is also concerned with the loss of agriculture bio-diversity, it has partnered with the Missouri Botanical Garden and St. Louis Universities to set up The Global Inventory Project. The project identifies wild perennial species that are breeding candidates for eventual seed stock development for perennial cereal grains. This instance provides an example of broadening the genetic biodiversity of grain crops. Breeding scientists and participating farmers will do further PPB development on the Land Institute's working farm.

This perennial project fits neatly with the Land Institute's long term goal "to advance sustainable agriculture and ecosystem security through the incorporations of perennial grain, legume, and oilseed species" in ways that most certainly include the sustainable ecological practices implemented on large scales (Jackson 1980; Glover et al 2010). Their actions to develop perennial wheat on a widespread basis are a testament to a new vision of crop possibilities that are good for soil and climate health. Two important features of perennial crops are the lack of soil and microbe disturbances through annual tilling and carbon sequestration in plant root systems (Science Direct, n.d.).

I had the opportunity to grow 3 stalks of perennial wheat in 2019, in addition to my other grain trials, so the Institute's perennial trials and long-term vision provide goals toward which to further work could be done in various regions in Canada. The climate differences across our country call for our own research explorations.

The Land Institute's video and audio library provides many insights into the range, not only of their land-based work, but also their embedded concerns for public education (Land Institute Library, n.d.). Potential changes are possible when informed people act together. This instance

of video and audio resources extends the understanding of PPB's impact in the face of climate change. It provides information, wise counsel, and direction for mitigating practices as well as new orientations needed for earth-sustainable food production.

Making such an education resource available extends the focus of my two research questions by enriching and expanding the viability contexts for PPB practices in face of climate. As farmers learn and share PPB practices and experiences, the very viability of the methods and their sustainable results will spread. As one of many resources available, the Land Institute's educational programs impact their participants directly and in ripple effects that move outward from initial points of contact. Such forms of impact expand my second research question about heritage grain networks by including and further developing the many types of expanded partnerships in which PPB and its offerings play a key contributory role.

As becomes clear from the work of the Land Institute, plant researchers and breeders are identifying the need to shift from issues like yield to include areas like naturally inbuilt plant disease tolerance and resistance, climate instability resistance, processing functionality, and enhanced nutritional value. The sustainability of emerging natural systems agriculture needs a healthy and diverse seed production system. Participatory plant breeding can help support the development of such a system. Through training of basic breeding skills and research practices, seed farmers can play a crucial role in building PPB breeding programs. These approaches, as well as the ones mentioned in the previous paragraph, focus my research questions with practical responses to exploratory questions about PPB.

3 PROBING PPB VIABILITY 2: CONFERENCES

As might be expected from the synergy that animates many conferences, this chapter contains a range of detailed information. The purpose of these inclusions is both descriptive of presentations and meant to stimulate thinking about what might be some possible applications to the Canadian context. The last section of this chapter indicates two other key points that emerged from the conferences, namely the need for education and training, and the need for collaboration.

3.1 1st International Conference of Wheat Landraces, Bologna, Italy

This ground-breaking conference was the first one to focus attention on wheat landraces. The presenters were researchers from universities around the world who were studying heritage grains for their health benefits. My husband and I were the only farmers there. These medical people were looking at various kinds of gut inflammation problems. Because our health is impacted by what we eat and how it's produced, this focus ties back to the contributions of biodiverse gene pools available in heritage and landrace varieties, plant breeding and growing conditions, and the way PPB methods can be used to explore how these and other factors affect people's health.

Such research work places PPB and its use of open source and heritage grain seed in a larger context of investigative health concerns. The diversity of genetic materials that are available for investigative breeders and farmers to grow permits a wide range of nutrient content in the resulting grain, which in turn may be tested for health benefits. This is why the biodiversity of heritage and landrace grains is so important. See Section 3.4.vii for a brief application relating to PPB heritage grains and gut health.

3.2 "Synergy That Sustains" – 9th Organic Seed Growers Conf, Oregon, USA

This conference was different from those in Bologna because it hosted a wide base of presenters including private plant breeders, breeders working with companies, other people involved in the seed sovereignty movement, and a number of international presenters. The next section provides some details of one important speaker who presented on a model that has clear applications to Canadian agriculture.

3.2.i Dr. G.V. Ramanjaneyulu, Indian Agricultural Research Institute

Dr. Ramanjaneyulu, the Executive Director for Sustainable Agriculture, told of the PPB successes he and his colleagues have had in re-establishing the viability of millet in India. This work has led to the development of over twenty millet varieties through forming collaborations with small farmers. In addition to the PPB crop work itself, they have developed a number of extended niche markets: having created many recipes for their millet and other crops, these industrious people also founded a book publishing company for their cookbook. Small cooperatives of women are now making specialty products. Because food functions as a basic unifier and serves as a very important role in Indian culture and identity, these innovative enterprises meet the social and economic needs of the people as well as providing for their nutritional requirements. Taken together, these partnering networks, through their PPB work, build the sustainability that is part of Dr. Ramanjaneyulu's mandate, by giving viable crops and a viable income for their participants (CSA India, n.d.).

Dr. Ramanjaneyulu's presentation provoked my thinking about his work's applications to the Canadian agricultural scene. He is an excellent example of a researcher who started asking questions outside the mainstream of research criteria. Some of those questions follow: How is our food produced? How are those engaged in production able to compete and make a viable living? How is production affecting the soil, water, and biodiversity? How are we choosing technologies and chemicals? What are the implications for health, the environment, and the economy of farmers, of regions, and nations? These questions were and are some of the motivators supporting his PPB work with small farmers.

My point in including these questions is that they are fundamental questions, to be asked as much in Canada as in India. This whole report can be considered as seeking to indicate at least some answers to the agricultural issues raised. However, we as individuals and groups have an informed responsibility to answer these questions as they apply to the particulars of our situations. The ability of PPB to adapt to local conditions is a key benefit.

As was stated, with the research work and support of Dr. Ramanjaneyulu and his team, their farmers and communities have been able to re-establish many varieties of heritage millet. In turn such actions have re-established interest and involvement from chefs and food manufacturers as they recognize the benefits of millet biodiversity and the economic value of heritage millet varieties. The extensive range of commercial activities noted above, that have arisen because of the millet revival, sets an impressive model of diverse enterprises applicable to the Canadian scene. Dr Ramanjaneyulu's millet project is similar to what Dan Barber has done by partnering with Row 7 in vegetable seed lines that are developed specifically for

flavour. “It’s participatory breeding, not independent of farmers, but with farmers. That also allows farmers to have more economic control of what they are participating in” — bringing them with chefs and breeders into the seed-to-table food chain to help create something new (Row7 Seeds, n.d.).

3.3 Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy

In my two roles as a Nuffield scholar and as a private business, I was privileged to be invited to this conference to represent Canadian agriculture. Just two weeks prior to this trip to Rome, a study had been released on the food policy in Canada (Food Policy in Canada 2019). Never before has there been an increase in world hunger and in obesity! (Endocrineweb, n.d.). At the conference, I really felt the collision between people starving to death and an epidemic of obesity (Ibid, n.d.).

As a result of this bizarre problem, all the United Nations’ countries are saying that we need to look at agriculture in new ways: we have to stop producing cheap commodities, stop producing wheat that is milled into low nutritional value white flour (SpruceEats, n.d.). With respect to cheapness, Bob Quinn, the Kamut grain farmer, noted in his article series on the “High Cost of Cheap Food” that: people’s health pays the high cost; the planet and the environment’s health pay the cost; the health of farmers and rural communities pay the cost (Quinn High Cost, n.d.). In one way and another, we all will pay the high cost of cheap food. While deeply aware of the financial food challenges faced by low and middle income consumers, there are additional long-term costs of cheap, lower-nutrition food, beyond the dollars paid upfront at the grocery store.

Because we need to rebuild our food systems, the United Nations recognizes the need for agroecology and valid PPB methods as important ways to actively contribute to change (FAO-UN, n.d.). PPB contributes because farmers know their land and know that soil health and fertility contribute to the nutritional value of the grain. This emphasis on nutritional grains ties in with the earlier “Wheat Landraces” conference in Bologna where presenters were talking about the quality of grains and the association of quality with how the grains are grown and processed.

In the months following this conference, a lengthy United Nations’s report was released by their High Level Panel of Experts on Food Security and Nutrition, along with a 13-page summary and series of five areas of recommendations aimed at food systems transformations. The summary’s title gives insight into its contents: *Agroecological and other innovative approaches*

for sustainable agriculture and food systems that enhance food security and nutrition (HLPE 2019).

Given the title, the summary gives a thorough explanation of agroecology as a transdisciplinary field and science that always needs to be integrated with "local and indigenous knowledge" (HLPE 2019. Section 1(d), page 10). It emphasizes regenerative rather than degradative practices, an issue at the heart of agroecology and PPB methods of sustainability.

One of the most important aspects of this conference and its report is that it gives precedents for those of us who want to do agriculture differently. For instance, the first section of the UN report's summary is entitled "Agroecology: Transition Pathways towards Sustainable Food Systems". The report targets 5 transition phases of which the second one suggests the use of agroecological alternatives in the place of conventional inputs and practices. As an example, I have tried adding volcanic basalt to soil as a slow release source of silicon. The Report's 4th point encourages re-establishing more directions and links between local producers and consumers, a feature of my own business model and practices (ibid, page 4).

Drawn from the UN's Report summary's recommendations which encourages activities to "support food value chain innovative platforms…" this Summary and Recommendations emphasises "supporting the development of local and regional markets, processing hubs, and transportation infrastructures so that farm and associated food products improve their access to local food markets" (HLPE 2019). Because of my local and regional marketing focus, the vision of having my own processing mill is focused by this point about food value chains and accessible processing hubs.

The international recognition of the various kinds of problems we face gives validity to national, regional, and local efforts to respond innovatively. Problems also offer opportunities. Synergy happens when we grow grains adaptable to our soil and conditions, when we grow low-input grains, ones that have high nutritional values, and are environmentally sound. These things are interlinked in ways that tie viability and impact into PPB. I'm looking at these issues as a farmer who has to make a living, pay the bills and mortgage, just like any other business. What I've been learning is that PPB seems to offer practical ways to grow income-generating crops that are good for the land and for people.

With agroecology being recognized internationally, there is an awakening to the importance of farmers as guardians of agricultural biodiversity. A 'one size fits all' approach to conventional plant breeding fails on the following counts: it fails the needs of small farmers, it contributes to the loss of agro biodiversity, it reduces the capacity of agricultural ecosystems to continue

producing renewable resources, it limits the ecosystem's ability to respond to climate change. While the UN's report points out these failures, its overall presentation is hopeful and resourceful in the very many specifics given to support the transitions and changes that are needed to provide for sustainable food systems moving forward. In a PPB program, adoption starts during the process of selection and precedes variety release. In a conventional plant breeding (CPB) program, the sequence is reversed. Other differences between a PPB and a CPB program include the increase of agrobiodiversity, which in a PPB program is higher because of the rapid turnover of varieties, and because the seed of new varieties is readily available to farmers, thus contributing to food security. Because of its decentralized nature, PPB can accommodate organic farms and become easily adopted by both national and international public breeding programs as one way of adapting crops to climate changes.

3.3.i Dr. Salvatore Ceccarelli (ICARDA)

One of the Rome presenters was Dr. Salvatore Ceccarelli, a world-renowned PPB plant breeder with over thirty years' experience working with the International Centre for Agricultural Research in Dry Areas (ICARDA) in sub-Saharan regions. His conference presentation and later, our dinner conversation with him, focused on the importance of PPB programs in places where they've already been experiencing the extremities of climate change for fifteen years and more – long before we even knew the word. He emphasized the need for seed adaptable to extreme climate and different soils, and that unless farmers and breeders understand the importance of landrace varieties, breeding programs won't succeed (Wheat Landraces 2019).

The sub-Saharan farmers have already felt the full brunt of climate change in farming and agriculture, especially in terms of increased heat and drought. The PPB research of Salvatore mentioned here, and that of Filippo Bassi mentioned shortly, are directed to such conditions. In their situations, PPB is already working in these harsh conditions, so it sets out an important example of developing adaptable crops (OUP Bioscience 2011). Based on his extensive experience and what he's learned from all the farmers he worked with, Salvatore feels certain PPB is going to be the only model that is adaptable enough to all the unpredictable weather patterns now occurring.

Salvatore is very concerned about monoculture breeding that focuses on premium conditions and ideal situations. In his view, it's just not equipped to adapt to the extreme weather we're now experiencing, especially with rising temperatures (Ceccarelli 2019). Drought in monocultures becomes a serious problem, as seen in recent years with failed corn crops in the American mid-west. Because there is a prevailing industrialized mindset focused primarily on

yield, he is concerned that the alternative PPB-related questions about other important crop characteristics are barely being asked.

When back home in Canada after our dinner conversation with Salvatore, I discovered that he and his team had received research funds from Canada's International Research Development Centre (IDRC) for work in Morocco, Syria, and Tunisia. This allowed them to do pioneering PPB work with farmers in these areas of harsh conditions and marginal rainfall. Farmers were treated as equal and respected partners with the breeders. As Salvatore told us, he had a considerable change of attitude when he realized the farmers knew more about breeding than he did. Because of the farmer-breeder involvements, he discovered that the speed of the seed selection process and the transfer and adoptions of new varieties was greatly increased. While these successful efforts in pioneering PPB focused on barley, farmers have now requested help with improving other crops.

These PPB developments are important because seeds and crops which are adapted to their actual growing conditions ensure that farming practices are sustainable. This is because the agroecological methods are adapted to the local conditions. They require fewer inputs and generate great biodiversity. Based on extensive experience and many successes, Salvatore has good reason to advocate that farmers have permanent participation in breeding programs (Vernooy 2003).

3.4 European Diversity Cereal Festival, Denmark, June 2019

Learning more about PPB happening within the countries of the European Union was my purpose in attending this important biennial festival/ conference. This program-packed, three-day conference on PPB-related cereal grain diversity included equally diverse attendees from universities, research institutes, agricultural and food authorities and organizations, advisory centres, food and beverage producers, networks of farmers, citizens, and rural actors. I was surprised, indeed overwhelmed, by the sheer numbers of established collaborations and partnering organizations both within countries and across national borders. Coming after the official year of Nuffield travels, this last conference both gave PPB-related perspective on all that came before it and significantly shifted my understanding of the far-reaching applications and implications of PPB.

Not only were research institutes sharing data but countries had partnered together to develop research strategies, develop multi-year trials, gather, collect, and disseminate a multitude of topics related to cereal grains, PPB, health and nutrition, food systems, environmental

concerns, business opportunities, seed gene banks and restoration, etc. The wealth of organization-derived information being so actively shared served to reaffirm the hallmark importance of PPB and its many practical successes.

I have selected a number of Festival participants and workshop presenters to serve as representative examples of the EU's collaborative wealth. My reason for these inclusions is that they are intended to spark the imagination and the vision for what is possible in Canada. These various examples of what is already happening in Europe may inform innovatively shaped counterparts here.

CERERE (CEreal REnaissance in Rural Europe), with partners in nine European countries, shared the Festival organization with the Nordic Heritage Cereal Network. A look at CERERE's website provides detailed information about its related projects focused on research and innovation activities (Cerere 2019). One such project links with "Let's Liberate Diversity", an organization concerned with developing and promoting the dynamic management of biodiversity on farms and in gardens (Liberate Diversity, n.d.).

A second project with a consortium of 49 partners in 18 European countries is "LiveSeed", a group dedicated to specifically support breeding activities to supply organic seed and suitable cultivars for organic food production. One of their projects is a survey of collaborative breeding opportunities for organic seed development. A third example from CERERE's network is "Diversifood", whose mission is focused on strengthening "food culture" and the sense of cultural identity that is associated with diverse ecosystems and the diverse plants cultivated within such systems (Liveseed, n.d. and Diversifood, n.d.).

One important point to emerge here is the collaborative nature of these organizations, a reminder of the Canadian partnerships already existing between the Bauta Family Initiative on Canadian Seed Security, SeedChange, and Seeds of Diversity, as was mentioned earlier.

Highlights from other selected conference presenters follow in the next sections; they're chosen to demonstrate, not only the wide range of presenters at the Festival but to stimulate the possibility of similar groups operating in the Canadian context.

3.4.i Dr. Filippo Bassi (ICARDA) – Farmers' Opinions Matter

Dr. Bassi shared fascinating PPB stories of his plant breeding work with Moroccan farmers in the sub-Sahara. He strongly emphasized the importance of attending to the identified needs of

the farmers involved in field trials and seed selection. His point was illustrated very concisely: one variety he bred looked very favourable to him because of high yield, large grain heads, and good disease resistance. However, the farmers didn't like it because the short stalks meant they wouldn't get enough straw to feed their livestock. By getting them involved at an early stage of seed development and selection, he saved time and money on a futile seed release that would not have made it to cultivation because of farmer resistance. Grain taste was another important consideration because what farmers grew they used in their own kitchens. (Icarda - Bassi, n.d.)

With larger concerns than seed development itself, Bassi has linked farmers with a women's cooperative seeking grain sources for couscous production. By strengthening the links between farmers and producers, such partnerships create greater income and community-involved profitability, both financial and social. The couscous cooperative has certainly created added-value while strengthening and supporting the roles of women in generating agriculture-related businesses (Icarda – Empowering, n.d.).

Bassi was awarded the 2017 Olam Prize for Innovation in Food Security for developing a strain of heat-tolerant durum wheat able to withstand the forty degree C heat of sub-Saharan Africa. At present, he leads a three-year project to evaluate crop-wild-derived varieties of durum wheat, barley, and lentil. This project is supported by the independent, non-profit Crop Trust funded thanks to the Government of Norway (Crop Trust, n.d.). Research into crop wild relatives helps to meet the adaptive needs of genetic diversity that tie into the preservation of existing species, wild and cultivated (Crop Wild Relatives, n.d.). The lament about the loss of biodiversity notes that once the genetic history of these long-adapted plants are gone, they're gone for good.

Filippo Bassio not only helped to develop a cereal grain that was adaptable to extreme weather but also one that the local culture was accustomed to. This is an example how PPB holds potential for cereal grains that the Canadian population is accustom to, or is interested in trying. Having a crop that can be viably grown in a specific area under extreme weather patterns offers much potential; again this is a model, or example, that can be implemented in regions throughout Canada. Corroborative story details about Bassi's valuable PPB work can be found at: (Major 2019; Stepman 2019).

3.4.ii Nordic Seed Company

Nordic Seed is a Danish company which focuses on strategic seed development responsive to climate change demands. As well as breeding varieties of wheat, barley, rye, peas, and field beans, another objective seeks to reduce pesticides in agriculture by breeding disease-resistant varieties. Improving the malt quality in barley and baking qualities of wheat and rye are also stated goals (Nordic Seed, n.d.). Cooperation in national and international breeding projects with public and private groups working on new breeding methods is also emphasized.

In being truly committed to working with farmers to help develop regional seeds, Nordic Seed Company sets an important standard of practice. As a viable business, it was very informative to hear details about their scientifically geared breeding programs and practices. In fact, according to one of their news items, this seed company attended the 1st International Wheat Congress in Saskatoon in 2019, a gathering interested in the findings of wheat breeding, genomics, and genetics.

Their emphasis on scientific research associated with regionally developed seed stock responsive to the changing climate is an example that could be paralleled in Canada. Within my networks and associations with farmers, breeders, and other growers, I'm aware of the need for producing sufficient seed stock that's adapted to Canadian conditions. There is a general shortage of sufficient vegetable seed here, for instance, that has begun to be addressed by the CANOVI collaboration mentioned. But a lot more research needs to be done to satisfy the growing demand for regionally adapted seed.

3.4.iii Aurion Cereal Processing Mill

Founded in 1974, Aurion has a reputation for organic cereal production in relation to ancient grains. Aurion claims to have the largest selection of grains in Scandinavia, with a product list that includes a huge variety of porridge, muesli, fruit rolls, and handmade chocolate, plus an extensive gluten-free range (Aurion, n.d.).

Aurion's presentation showed clearly that they had the foresight and targeted business strategies able to develop many "value added" products connected with their grains. Using the variations on milling and flaking grains allowed them to produce targeted items clearly addressed to a range of niche markets (ibid, n.d.). It was impressive to see how the company had grown from one small farm into such a large market share. Based on the company's commitment to use heritage grains, Aurion shows a viable model of scaling up that sets an

example for others to follow. Its innovative and visionary planning allowed it to fill a market gap in ways that could stimulate Canadian entrepreneurs to do likewise.

3.4.iv Crop Trust

Crop Trust's home page succinctly sums up the pressing global problem of biodiversity loss: *Crop diversity is **essential** for life on earth. It underpins nearly everything we eat and drink. **But it's rapidly disappearing*** (CropTrust, n.d.). In a very direct way, Crop Trust pinpoints 6 reasons for taking active measures to protect crop diversity and the biological basis of our food supply. Its work:

- ensures food security
- adapts to climate change
- reduces environmental degradation
- protects nutritional security
- reduces poverty
- ensures sustainable agriculture
  (CropTrust Mission, n.d.)

Crop Trust officially began its seed and genetic conservation work in 2004 when the International Treaty on Plant Genetic Resources for Food and Agriculture came into force. With 194 countries party to this treaty brought into existence by the Consultative Group for International Agricultural Research (CGIAR) and the UN Food and Agriculture Organization (FAO), Crop Trust's work is meant to serve the tenets of this internationally agreed upon Treaty. One extremely important facet of its diversity mandate is the Svalbard Global Seed Vault, a global gene bank partnership to conserve the genetic heritage of diverse crops. A second important facet provides permanent operational costs for various seed conservation collections. These global collections are supported through its Crop Diversity Endowment Fund with monies contributed from 50 countries. In addition, Crop Trust supports selected research and conservation projects such as the one led by Filippo Bassi mentioned above. Reliable permanent funding for seedbanks is a perennial problem, and as Canadians, our government and our citizens need to pay to support the seed legacy needing to be handed down to our next generations.

Food security, in its many forms, is a primary motivator of Crop Trust's work because crop diversity is so seriously threatened by habitat degradation, invasive alien species, and over-exploitation. In the face of climate change, the importance of the gene bank partnerships and the permanent funds to support it can never be overestimated. Part of the ongoing context that

frames Crop Trust's work derives from the International Treaty on Plant Genetic Resources in Food and Agriculture Report (PGRFA) signed in 2001 by 144 countries. The Plant Treaty set up a Multilateral System (MLS) with the purpose of giving global access to certain plant genetic materials by farmers, plant breeders and scientists in exchange for ensuring that the derived research benefits are freely shared in the countries that supplied the genetics.

This inbuilt reciprocity and interdependence is based on groupings of 64 of the important crops (Multilateral List, n.d.) most essential to global food security and nutrition. Again, I draw attention to the crop research led by Filippo Bassi as it is sponsored under the MLS with the understanding that the seed development and resulting resources are made readily available.

Because open source seed is foundational to the work of PPB, seed banks and their rich genetic materials are an invaluable present and future resource. This is closely allied with my first research question about PPB viability, and as such I see support for seed banks as crucial to preserving and extending the genetic heritage of which we are but the present recipients. As was noted earlier in lamenting the loss of biodiversity, once it's gone it's not coming back. As Canadians one of our essential responsibilities is to safeguard our biodiversity heritage.

As it happens, Crop Trust's conference presentation also raised the huge issues around seed patents generally, and around the question of who owns the genetic rights for breeding and the seed developed from PPB. Another concern was how private seed breeders can stay competitive with large corporations. Such issues as these raise questions that need addressing. These questions require significantly informed input beyond the scope of this report.

However, I would like to comment on a seed-related availability problem mentioned at the conference that arises for varieties suitable for specialty markets. The large number of seed industry mergers and mega-mergers in recent years, like Bayer buying Monsanto, has resulted in increasing monopolies. The large amounts of commercial seed being produced and sold worldwide are being sold by fewer and fewer transnational companies.

After such mergers, I was informed that a combined product list is compiled from each component business to note the seed varieties in the order of their sales. Any varieties that fall below a certain level of profitability are dropped, even though they may have been very successful sales items for smaller companies (KCP Opinion 2018). In terms of genetic erosion, the serious problem is that the specialty seed varieties that could serve very important niche markets in various regions are no longer available. In the name of economic profitability, this example presents the loss of biodiverse profitability and its incalculable value.

3.4.v Dynaversity

Given the progressively threatening 'genetic erosion' of the last one hundred years, Dynaversity is a consortium set up in response to the PGRFA treaty mentioned in the previous section (Dynaversity, n.d.). In the concern for genetic conservation, its strategic efforts are particularly focused on "conserving diversity in situ: in agriculture and the food chain", a complement to the ex situ work of gene banks (ibid, n.d.). Their strategies seek to make sure that viable plant species continue their existence in the places that gave rise to their particular characteristics.

One major advantage of in situ conservation assures the evolutionary adaptive processes of plants in their actual conditions, an important resilience factor in relation to climate change. The accounts of Georgian wheat and Estonian rye mentioned earlier in this report illustrate the kind of in situ strategies which Dynaversity is advocating. Those two particular illustrations showed the strong interdependence of their respective national crops with the food chain and their food culture identities.

To help to actualize the work of the PGRFA Treaty, Dynaversity contributes analytics of the major in situ players so that it can then put forward adapted models of management and governance. Such models include building new networking arrangements able to support in situ developments. With an eye to diversity management, its mandate includes the partnerships between science and practical agricultural knowledge that facilitate evolutionary and site-specific adaptation.

In order to further one of Dynaversity six stated objectives, that of generating a knowledge base, it has created the Sharing Knowledge and Experience Platform (SKEP) as a means of ensuring collaboration and networking between in situ actors and stakeholders. This important tool allows best in situ practices to be readily shared so that intentions for plant conservation can actually take place in practice.

Dynaversity's data base platform and its use of digital technology reminds me of the new interoperable platform launched in July 2019 by the American OpenTEAM project. This system intends to provide farmers around the world with soil health knowledge in the context of regenerative agriculture (Wolfe's Neck 2019). As a helpful and practically oriented servant, these types of technology platforms facilitate the kinds of global collaborations that will be needed to address the climate changes that affect us all in our respective locations.

Dynaversity's mission made a deep impression on me because of the extensive international network of players - farmers, gardeners, researchers, environmentalists, food processers, and consumers – all seeking to maintain and re-establish agricultural bio-diversity in the face of

accelerating losses. Given the international nature of Dynaversity's partnerships, the digital age makes these knowledge-sharing relationships possible, including Canada as a contributing player.

3.4.vi Swedish Farmers' Coop

Because of the difficulties in 2004 of getting access to good quality seed, one grain-growing farmer/ festival presenter from Wästgöterna, Sweden, started trialing some old varieties of grain and then formed a cooperative with 7 other farmers. Fast forward 15 years: they now grow 6000 acres of heritage grains, do their own plant breeding, and supply to markets they've developed. Each of the 7 farms specializes in grains like rye, spelt, wheat varieties and then they come together with their soil- and weather-adapted grains to sell collectively. Because of this collaboration and the thousands of tons they produce, they can approach large buyers, to mutual benefit. (FolkFusion, n.d.)

This partnership has been innovatively extended because they now have 50 specialty products. They bought their own mill so they can crack, roll, or flake grains according to product demands and preferences. They also own a cereal-making company. Developing 'terroir' stories has been an important part of their marketing strategies, stories to which consumers and health-minded consumers are responsive.

This farmers' cooperative serves as an example of the a scaled-up niche market opportunities that are available. All too often the word 'niche' conjures up a small and perhaps marginal enterprise so this example puts PPB and its partnering innovation into a sustainable framework. I had the opportunity to visit one of the coop farms so it was heartening to see the described work actually taking place in situ.

AtG vignette: The Against the Grain Farms' business model that I've developed and continue to modify in response to market opportunities finds inspiration in the Swedish Coop example. Because this group of farmers developed specialty-aimed collaborations in relation to the grains best suited to their lands, I see that this offers possibilities in my own Eastern Ontario region. In my work to demonstrate PPB's viability in my region, the Swedish example provides another dynamic example for the cooperation that makes scaled up production possible and sustainable. The range of their value-added products is both an inspiration and a complement to ones I've been developing and selling.

3.4.vii Andrew Wilkinson, Gilchesters Organic Farm, England

Having first met in Denmark, Andrew Wilkinson later pursued our shared interests in black and purple barley (Gilchester, n.d.). He works closely with a sourdough baking teacher whose courses have been recommended to GPs by the UK Council of General Practitioners. The Council wants to educate its doctors on the importance of sourdough for gut nutrition and health. Black and purple barleys have been identified by researchers as important for recovering cancer patients because of their anti-inflammatory properties. These grains are said to be able to buffer the impact of cancer treatments on the gut wall (Wilkinson 2019).

Because we ourselves grow these old varieties that have much higher beta-glucan levels, Andrew requested some seed he could trial on his farm located in northern England. He's hoping to grow them out sufficiently to offer to the sourdough teaching classes (Wilkinson 2019).

This example of enterprise clearly links PPB-produced grains with important medical research and GP education. It also ties back to the section on the Wheat Landraces conference in Bologna where nutritional factors in landrace varieties were being explored. I mention Andrew's example as but one instance in a rapidly expanding field of research. However, given the complex nature of the topic of modern grains, production methods, and posited health problems like gluten sensitivity, the topic requires a more nuanced approach than I can deal with in this report.

That being said, here is just one gluten and sourdough-related webinar presented by Cornell researcher Lisa Kissing Kucek, entitled The Grounded Guide to Glute (Youtube, n.d.). This informative research study nuances gluten in helpful ways, raising questions about other possible contributing causes of gut ailments, and then shows the interactions of gluten and sourdough fermentation processes. While drawing some helpful conclusions, Kucek raises a cautionary flag about gluten's role in ways that helped me realize that much more research is needed in this area.

The European Diversity Cereal Festival, scantily glimpsed in the few selections just featured, served as a game-changer for me. To be exposed to the great diversity of presenters and with many opportunities for stimulating conversations with other attendees has been quite transformative. These few conference selections serve to give some idea of the scope that was on offer, a PPB-related scope I could never have imagined before I attended. The experience provides a fitting completion to the travel opportunities sponsored by the Nuffield scholarship.

3.5 Summary of Key Chapter Points

This last section considers a number of key points emerging from the conferences I attended. Because of the wealth of detail covered, I've worked to present applications to the Canadian context as the chapter has progressed, so I don't intend to cover points already made. However, two cumulative areas stand out for specific mention.

3.5.i Education and Training Needed

My own PPB experience plus my country travels and conference attendance underscores the need for education and training for people in the agricultural sector. Learning opportunities include conferences and workshops of various lengths, field days, webinars, focused education days for seed to table partners, and/ or mentorships of many kinds. The possibility of a consultable database, or even a list of reliable digital education and training opportunities specific to PPB could also be of service.

Two branches of agroecological education and training are also indicated: one is wide-ranging with respect to an extensive array of agroecological practices that could be implemented; the second focuses more specifically on equipping PPB farmers and other seed growers with the know-how needed to do on-farm breeding. With respect to dealing with this latter point first, the website for Natural Systems Agriculture at the University of Manitoba has extensive educational resources, including text and clear photos illustrating actual plant breeding methods (UManitoba – Natural Systems, n.d.). These are meant to instruct farmers in the specifics of grain breeding. Other extensive digital resources exist and are being created for our instruction.

Specifically focused education and training, however delivered, can help PPB seed producers to scale up, diversify, and learn how to increase the quality and quantity of their ecologically produced and regionally adapted seed. Building supportive communities of like-minded practitioners could provide peer exchanges on seed production technicalities, business strategies to develop and grow a seed business, or strategies on conducting on-farm research.

Regional training opportunities could facilitate farmer-to-farmer exchanges, develop the skills and knowledge of local seed stewards, and provide learning opportunities for those people who are not direct program participants and want to learn more about in-field work. Some of these points aren't directly aimed at learning plant breeding methods but serve as important educational adjuncts, depending on the needs, time, and interests of attendees, and address

the core issues of the contribution of PPB as a response to climate change and its impact on heritage grain networks.

3.5.ii Collaboration

Because the European Diversity Cereal Festival in Denmark occurred more than 6 months after the conclusion of my official Nuffield year of 2018, the time gap gave me a chance to pause and reflect. As a result of that gap, the theme of collaboration became very clear. The diverse Denmark material is meant to substantiate this important point. Again and again, I was aware of the many inter-regional and European groups working together to extend their respective missions through cooperation, partnership, mentoring, and cross-border research projects.

Though this collaborative theme is also reflected in other places in this report, the Denmark conference provided collaboration with a special clarity. Collaboration also involves the building of community to generate the critical mass needed to make the many kinds of transitions – and not just agricultural ones – required in the face of climate change. This is one very important lesson that applies to Canadian society overall, as well as more specifically to the agricultural section that is the main focus of this report.

4 TERROIR IDENTITIES AND SEED TO TABLE PARTNERS

After delving into the meaning of terroir as a term being applied to heritage grains, I will explore the benefits of establishing and promoting such a terroir identity. Such an identity can operate along the collective partnership lines that move between seed and table; at the same time, each partner may be able to build and use the identity to establish and uniquely position their own particular businesses, markets, and other creative food offerings meant to generate income. In a number of definite ways, PPB has the ability to help its seed to table partners to create their own distinctive terroir identities.

The purpose that undergirds this chapter relates to my research questions by showing the viability and impact that PPB gives to seed to table partners and how it can relate to niche and scalable markets. As well as generating income, various seed to table partners can educate each other about food sources, growing conditions, sustainable agricultural practices, food production methods and other such things. This education helps to meet consumers' needs for reliable knowledge so they can make healthy food choices. As well, such educational opportunities can stimulate the creation of meaningful social interactions and relationships.

4.1 Defining Terroir Identities

Picture French vineyards and exclusive wine labels: the exercise clarifies the meaning of 'terroir', the French word for 'soil' and for things 'local'. The three Bs, Burgundy, Beaujolais, and Bordeaux claim for their respective selves certain distinctive and distinguishable qualities that set them apart as wines and as regions. Particular soils, locations, climate conditions, and seasonal variations in weather and growth, interact with carefully tended grape vines, very often vines and locations with long pedigrees and histories.

The combined local conditions impart unique flavours or tastes that are identified as characteristic of a particular wine as it's grown in a particular season; the very locale contributes to its unique identity. A rich descriptive wine vocabulary has become part of the traditions that surround terroir identities. Wine bottle labels give many imaginative terms to indicate the wine's flavour and body.

By extension, terroir is now being applied to foods with distinctive tastes and nutritional contents. Greek olives and regional-distinct olive oils, Italian pasta, English regional cheeses, - these are representative examples of long-promoted food products that highlight their distinctive local qualities. Terroir is now being applied to heritage wheat and other cereal

grains. Unpacking its meaning and extended usage at this point is intended to show its root heritage and to build on contemporary contexts of application.

"Does heritage wheat really have a distinctive flavour?" you may ask. "Yes" is the immediate answer given by Dr. Steve Jones of the Bread Lab and by Lali Meskhi and Mariam Jorjadze from the Republic of Georgia, three people mentioned earlier. The Lab's many organized and random taste tests confirm that heritage wheat varieties from differing areas have truly distinctive flavours, especially when the 100% whole grain flours are freshly milled. Though still lacking a sufficiently differentiated vocabulary to accurately describe the taste differences, Bread Lab testers can taste the distinctiveness of various heritage wheat varieties (Lawson 2016).

The Georgian vocabulary of Lali Meskhi and Mariam Jorjadze is "wheat-rich" - as befits its central position in Georgia's cultural and agricultural identity. The wheat inventory research done by Mariam Jorjadze and her colleagues made an interesting vocabulary discovery. It seems that the local people gave proper names to their distinctive landrace varieties based on their local wheat's particular qualities (Jorjadze 2014). As distinctive wheat landraces are so deeply embedded in Georgian agriculture, it's easy to understand that their longstanding wheat vocabulary is equally embedded in their food culture and in their overall social and cultural identity.

Georgia's regional wheat differences and resulting language descriptions can be understood as examples of already established terroir identities, ones that they can build on and nuance for their contemporary circumstances. Contemporary nuances become the applications of traditions that live on in new and evolving forms.

4.2 The Benefits of PPB-Derived Terroir Identities

The benefits of PPB-derived terroir identities to be outlined in this section are derived from plant breeders and seed growers and many others involved in growing food sustainably. As well, the benefits come through the many connections with researchers and food industry people established by my Nuffield travel countries and conferences. Though not exhaustive, these contacts include store-front and farmers' market bakers, chefs, restauranteurs, brewers, distillers, maltsters, other food producers, food businesses, educators, and consumers. As well, my own experiences as a PPB farmer, product marketer, and educator, provide deep wells of reflective insight upon which to draw. Based on such bodies of substantiating evidence, I want to share a number of important benefits that have emerged into greater clarity.

4.2.i The PPB Advantage

Though PPB may be considered by some as a niche in Canadian agriculture, the points already made about its viability and inherent generative power to adapt to its local environment gives it an exponentially expansive presence and a climate-responsive power out of proportion to its size. The fact that PPB and its heritage grains grow from adaptable seed contributes to using sustainable growing and production methods. Such methods are becoming increasingly important for all those concerned with protecting and promoting environmental as well as social justice. With expanding bodies of research exploring and confirming the nutritional content of heritage grains and other plant-based foods, this point is also becoming more significant for many, including those suffering from food-related ailments.

Though other factors could be named, in my opinion certain summary advantages of PPB can be distilled:

- generative power and presence, not size
- viable and sustainable methods of food growing and production
- environmental and social justice protection
- practical and ethical applications promote social health and spiritual well-being
- nutrition and digestibility support physical and emotional health
- research-oriented and supported

These 6 summary points can be expanded in many ways because of the nuances and implications that can be developed from them. As well as any others that arise, these points give seed to table partners certain specific PPB-focused advantages through which to develop and promote terroir identities. PPB farmers can uniquely position themselves and their grains with terroir identities; the PPB advantages flow into support and encouragement for other seed to table partners to create their own PPB-based terroir identities in ways that readily distinguish their food products and services.

Using these few summary points, it becomes apparent that innovative entrepreneurs can leverage their terroir identities using the PPB grains and products as means that contribute to that identity. These PPB advantages carry and create a terroir identity impact, an impact related to my second research question.

4.2.ii Advantages of Terroir Identities for Seed to Table Partners

Moving on from more directly focused PPB farmer contributions, the advantages accruing from PPB associations can be used by groups and individual partners to develop and sustain their

own businesses, markets, and food services. The point form delivery here is meant to stimulate readers to pause and reflect on the kinds of factors that partners can use to create and effectively position their own terroir identities. Establishing their particular identities and reputations helps them to leverage the potential of their niche markets to their advantage.

Advantages of PPB associations:

- authority and validity derived from PPB advantages flows into partners
- authenticity of undisputed food origins, sources and growing methods
- quality assurance and product/service credibility
- customer loyalty promoted through PPB and associated advantages
- better consumer education about PPB heritage grains and products
- improved consumer education about expected seasonal variations
- buying local creates and contributes to regional identity and support
- buying local supports local economies so they become more self-sustaining
- significant niche identities and markets established
- income generated for partner businesses, products, services
- enables value-added spin-offs generated by innovative partners

As well as tying back to the points listed in 4.2.i about the PPB advantage, these points also tie back to the two research questions that have shaped this report. They provide explanations and rationales that help to distinctly situate PPB farmers and partners in the market place. It is important to debate issues with more than economics in mind.

4.3 Terroir and Partner Applications

In commenting on the Benefits of PPB-derived terroir identities in Section 4.2, I noted the substantiating evidence from which 2 areas of summary points in that section were drawn. In this section, a brief focus on selected terroir-related examples will be used to anchor and apply the summary points. These anchoring examples come from my Nuffield travels and are intended to show various applications to the Canadian context.

The Bread Lab's research facility gives authority and validity to the PPB grain trials that bring together plant breeders, and bakers and chefs. These research-based partnerships promote the terroir identities of their various actors in ways that have impacted the Cascadian region's identity and authenticated the heritage grain market. The cooperatively developed regional branding allows consumers to readily identify and thus buy the specifically labeled products. Customers can be assured not only about the quality and nutritional value of their purchases

but about the environmentally responsible conditions from which the food came. The following are some examples of this in action.

4.3.i E5 Bakehouse

The ES Bakehouse in London, England is a fully integrated bakery that contracts PPB farmers to grow different heritage grains based on their baking qualities (ES Bakehouse, n.d.). The bakery's on-site mill enables the facility to custom blend the different varieties of wheat flour – a value added process. They don't produce bread based on a certain recipe, but rather develop breads based on what their farmers produce. Such authenticating collaborations allow their farmers to work with PPB because every crop is considered viable and valuable. With this process, the E5Bakehouse educates consumers about crop variations while assuring product quality. The E5Bakehouse customers learn about the terroir of the grains and became more engaged in bread baking processes. Such varied activities build customer loyalty in ways that actively support their terroir identity while supporting local economies. The E5Bakehouse provides a model of investing in the whole cycle of bread baking that is a stellar example of the impact and viability of seed to table partnerships.

4.3.ii Kuusela Sourdough

Elissa Kuusela is a Finnish sourdough baker I met at the Danish Wheat Conference. Her practical and cultural work has re-established significant market connections between regional farmers and bakers willing to grow and use older PPB-grown varieties of Finnish rye. She writes authoritative cookbooks, speaks internationally, and is engaged in an international movement to re-introduce rye breads into mainstream eating habits. She hopes to visit Canada with a photographer able to document her work and its embedded values. This visit would provide educational footage for new niche market projects with more English content. Elissa's advocacy to restore Finnish cultural identity and heritage is a spin-off example that significantly impacts rye's terroir identity. Her many value added innovations show various income-generating projects. She's created a significant niche identity for herself and her heritage rye projects.

4.3.iii Culinary Breeding Network

The Culinary Breeding Network originated with the research initiative of Professor Lane Selman at Oregon State University (Culinary Breeding, n.d.). The Network is concerned with community building between PPB plant breeders, seed growers, farmers, produce buyers, and chefs in order to improve the quality of grains and vegetable. These kinds of partnership exchanges serve mutually beneficial goals because they:

- Promote and expand awareness of cultivars created by public and independent plant breeders using traditional plant breeding processes
- Increase communication and collaboration between stakeholders in the food community in order to create more relevant and desirable cultivars.
- Identify cultivars and traits of superior performance, flavor, texture, culinary attributes and overall quality

All the Network players from 'seed to chef' are active participants with a strong education role to complement the other activities. Their community building partnerships allow the entrepreneurs to develop particular terroir identities for their crops. The chefs and bakers work to develop niche markets because of the partnerships that generate support for such innovative developments.

4.3.iv Red Apron

The Red Apron is a small local Ottawa business that produces and sells prepared take-home meals and other food products, including items using my heritage grains (Red Apron 2019). With innovative flair and market positioning, the store has put together a "100 Mile Menu" available for 5 Thursdays starting in September 2019. The store sources all its selected menu items based on the sustainably produced raw ingredients supplied from other local food producers of vegetables, meats, grains, beverages, located within the distance limit. This clear response to transportation costs and local employment shows this producer's innovative ability to partner with local suppliers and generate local economy income. Equally important, the 100 Mile Menu creates an education opportunity and talking point for its customers. The menu substantiates a local terroir-like identity, not only for itself but for its participating regional partners, while it also assures quality and stimulates customer loyalty. Clearly, terroir identity can be situated in locally profitable niche operations that are equally good for people and for the environment. The Red Apron portrays a locally focused and representative model of the local food initiatives targeted in Canada's National Food Policy and the United Nations document on sustainable agriculture and food systems.

4.3.v Mungoswells Malt and Milling

Visiting the Mungoswells Malt and Milling Farm in East Lothian in Scotland re-iterated the importance of locally grown PPB barley for distilling (Mungoswells, n.d.). Angus McDowall had been farming for over 35 years' experience growing malting barley for large grain distiller, like many of his fellow farmers. When the bottom fell out of that market in 2008 due to the global

financial crisis, he like many other area farmers were left without a barley buyer. True to Scottish farmer tenacity, Angus spearheaded the establishment of a small micro distillery. He began to trial different varieties of malting barley unique to his area, developing strains specific to the region, and responsive to the local climate and soil conditions and the culinary preferences. As a measure of his success, Angus is now contracting other farmers in scaled up cooperatives to help fill the ever-growing demand for his speciality malting barley.
Because I have recently released some of my heritage grains to a distiller wanting to produce bourbon, whisky, and vodka, Angus's example inspired my own marketing strategies.

In addition to the malting and distilling, the wheat milling and valued-added products are grown, harvested, milled, and packaged within 20 miles. Angus' integrated system bespeaks a local terroir identity and scaled up niche market which allows the business to justifiably brag on its website about its "quality local produce with unrivalled traceability" (Mungoswells, n.d.).

4.3.vi Slow Foods

"Slow Food® in Canada" is part of a global, grassroots organisation working to enhance local food cultures and prevent their disappearance (SlowFood, n.d.). Frequently held at fairs under the banner "Taste of Diversity", the organization provides a variety showcase in which the plant breeders, chefs and public are able to be involved in selecting seed that is of most interest and with desired taste qualities. This increases farmers' knowledge of current trends and consumer-desired attributes, thus helping to drive demand and to develop value chains. Such practically-oriented education gives ways to test the market possibilities. It helps to build the consumer awareness which in turn influences food trends and market demand. An exemplar is the Lanark County Slow Food group which works to promote heritage breeds and seeds as part of its mission (Lanark County Slow Food, n.d.).

4.4 Consumer Participation and Education

Consumers as 'mere recipients' in a top-down process over which they have no control or input is an important problem. In some ways, it can parallel the marginalization that modern farmers have faced in corporate processes of seed development and plant breeding, mentioned earlier in this report. The example of the active farmer participation that happens in PPB can serve as a consumer-oriented model. The farmer's fulsome participation in PPB practices encourage consumers to be similarly active participants in their own education.

Gathering information about food sources and food production is one area for active consumer participation. Often health problems or environmental concerns will motivate consumers to become better informed about the sources of the food, the conditions in which it's grown, how it's processed, its nutritional value, etc. Because consumers can choose to be community partners in seed to table networks, food education is becoming increasingly important to them. I'm very aware of this because of my weekly attendance at a local farmers' market. Given the epidemics of food allergies and the staggering rise in diabetes and obesity, many consumers want to know more specific details about what goes on their plates and in their bellies (NIH 2013, Endocrineweb, n.d.). Educating consumers about PPB and its benefits plays an important role that allows consumers to make educated choices that accord with their dietary needs and their food, social, and environmental values and commitments.

As associated aspect of consumer education would benefit from a better understanding of the importance of seed system conservation, an essential component of PPB's ability to provide nutritious food. In the seed to table partnerships that focus certain features of this report, the point being addressed here concerns seed education and awareness.

Viable, open source seed is an essential part of our human heritage and needs to be conserved and protected. The heritage seed associated with PPB means that farmers can create farmer-driven market systems responsive to consumer needs based on characteristics like:

- Flavour
- Nutrition
- Variation
- Niche market demand
- Low input costs
- Good for the land

Such a list of desirable qualities applies to fruits and vegetables, to beans and pulses, as much as to the grains that have been the primary focus here. Plant breeding needs to contribute to the 3 "Ps", not just profit but also people and planet.

AtG vignette: As a PPB farmer and entrepreneur, I continue work to establish a terroir identity for the heritage grains I grow. This identity is one that flows naturally to my seed to table partners and allows them to create their own distinctive terroir identities in ways that are mutually beneficial. Through the work and the knowledge gained from PPB, I've been able to develop a niche market and now supply distillers, brewers, food manufacturers, provide retail items for consumers and wholesale quantities for chefs, bakers, restaurants, and commercial

kitchens. The point of sharing these details is to encourage other Canadian farmers with the possibilities and potential associated with PPB.

As an educator, I'm very aware of the consumers yearning to know more about sustainable food systems, to know where their food comes from, to understand the importance of open source seeds, etc. as they actively seek to live from a new consciousness of their environmental responsibilities. Many consumers are hungry for a food culture and identity that can sustain them, body and soul.

5 CONCLUSIONS

This report was framed by two exploratory questions about participatory plant breeding's viability and impact, questions that have been addressed by the contents of its respective chapters. Not only is participatory plant breeding (PPB) a viable response to climate change, it is also a very necessary response to many ecological factors including those of soil health and nutritional food. Confirmation of PPB's viability has occurred in many of the examples given throughout this report, with many voices advocating for its importance and its applied practices.

Global warming, whatever its contributory causes, is already disrupting our weather patterns and impacting food productions, in Canada and around the world. PPB shows itself to be an informed, adaptable, and viable response to the many climate uncertainties we face.

The very publicly acknowledged viability of participatory plant breeding is seen in the 2017 Olam Prize for Innovation in Food Security awarded to Filippo Bassi. He and his team developed a strain of heat-tolerant durum wheat able to withstand 40 degree C (Section 3.4.i). This remarkable acknowledgement is representative of the work of many others using PPB to substantiate the viability claim of PPB in relation to climate change adaptability and resilience.

As well, this report has traced numbers of representative examples of the existing impact and the innovative potential of PPB on the seed to table partnerships. These partnerships and their associated terroir identity developments connect heritage grains and their contemporary offspring in overlapping community networks. Examples included the Bread Lab of Dr. Steve Jones and his team, section 2.4.ii, and the McDowall family's Mungoswell Malt and Milling initiative, section 4.3.v.

Such examples highlight the development of PPB methods that have allowed these entrepreneurs to develop significant seed to table partnerships that support significant social and financial impacts. Their respective regions in the north west United States and in Scotland have benefitted greatly through the impact of their networks and growth of markets for their products. These and many other examples in this report serve as important models for Canadian entrepreneurs oriented to PPB and its seed to table impact.

Participatory plant breeding has the potential to become main stream provided all levels of government implement the public and civic policies needed to make publicly funded seed genetics freely available. Access to seed and its genetic resources and to the necessary research investments are issues far too important to be left to private corporate interests alone. As

mentioned earlier in this report, developing and maintaining secure and sustainable food and nutrition requires as broad a genetic base as possible in the face of biodiversity losses. Genetic diversity, and therefore seed resilience, are currently impeded, in my opinion, by the highly protected material produced and managed by private breeding and patented intellectual property and its associated monoculture framework. Broadly based genetic diversity certain helps to mitigate the increasing problems of climate-generated monocrop failures.

Governments have the ability and the power to serve the common public good by their own investments in seed and plant breeding as that most basic source and foundation of our food systems. The plant breeding research work being done in various Canadian universities are innovative as far as they go in stretching their resources. Such research is certainly one area well-deserving of public funding, given the governmental challenges and policies need for secure and sustainable food production and accessibility. While this report has touched on such breeding programs, much more needs to be done to support such public enterprises because their many paybacks benefit us all as Canadian tax-payers.

Climate change already impacts our food systems, though it may not yet be obvious during a trip to well-stocked grocery stores. Talking to farmers at our local markets, however, enables us to hear their real-time stories about the particular impact changing weather patterns are having on their ability to get food to our tables. As a farmer myself, I know this reality and that thin line between crop success or failure – a line intimately tied to making a living, paying my bills, and caring for my land. In that respect, my story shares in the story of all farmers – we are living at the mercy of precarious environmental patterns and conditions beyond prediction. Such conditions most certainly impact seed to table networks.

Out of such a basic seed and food-producing context, the complementary work of participatory plant breeding offers hope. That hope formed the basis for the explorations detailed in this report. The developments of living seed stock and plants resilient and adaptable to the undeniable weather changes being witnessed everywhere offer projects worthy of further exploration and investment.

PPB offers hope, and more, it invites the practical methods for a food-sustainable future based on the agricultural wisdom and practices embodied in agroecology. Earth-renewing agriculture, in contrast to the depletion practices in modern farming, is a regenerative story now in the process of being written. It's an epic in the making. The hope that founds and fills such a regenerative story entices with its array of viable possibilities and humanely ventured opportunities. Participatory plant breeding is set to be a major player in that story's unfolding development.

6 RECOMMENDATIONS

6.1 PPB-Related Actions:

- Promote decentralized PPB programs as viable options contributing to the long term resilience of agricultural production and agroecological food systems.
- Train more farmers to do on-farm PPB research by developing profitable incentives.
- Use mutually agreed research designs and objectives to help to meet practical farmer needs, plus reduce the researcher's variety development costs. Shared objectives help the acceptance of new adaptability-proven varieties.
- Focus PPB on renewing minor cereal crops adapted to local and regional growing seasons and conditions, based on farmer-PPB data and network partner needs.
- Empower direct-experience farmers to participate in developing genetic material characterized by high biodiversity. Climate resilience requires both crop diversity and intra-crop genetic diversity.
- Integrate formal and informal plant breeding research into seed adaptability in the face of climate change.

6.2 Seed To Table Network Partners

- Develop both sustainable seed and value-added food and drink products (Section 4.2)
- Develop terroir identities and variously scaled niche markets that await freshly innovative and inventive entrepreneurs.
- Directly link consumer education and involvement to healthy food trends that access value-added networks and newly emerging, eco-sustainable market demands.
- Build consumer awareness of PPB as a viable and sustainable food production method based on the rich experiences of traditional plant breeding processes.

6.3 Institutional/ Governmental Policy Making

- Directly involve PPB programs in discussions and planning concerning eco systems and agro-biodiversity because seed is the most basic and important item of the food chain.
- Develop fair and green policies to support new breeding organizations.

- Develop support policies and practices that allow PPB to more directly contribute to the issues of agroecology, people and planet, and not just financial profit.
- Expand registration protocols beyond distinctness, uniformity, and stability, to include low input costs, weed suppression, disease resistance, and human nutrition.
- Work towards PPB as a viable mainstream method, rather than merely a minority interest.

7 GLOSSARY

3Ps	People, Planet & Profit
CCCR	Canada's Changing Climate Report
AGRO-ECOLOGY	Ecological processes applied to agriculture production
ECRI	Estonia Crop Research Institute
FAO	Food and Agriculture Organization, United Nations
GWGA	Georgian Wheat Growers Association
HLPE	High Level Panel of Experts
ICARDA	International Centre for Agricultural Research in Dry Areas
IRDC	International Research Development Centre
Landrace	A local cultivar that has been improved by traditional agriculture methods
NFP	National Food Policy
PPB	Participatory Plant Breeding
UN	United Nations
UoM	University of Manitoba
UoW	University of Washington

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9 APPENDIX

9.1 Participatory plant breeding for Canadian organic crop production

What is participatory plant breeding (PPB)?

- Participatory plant breeding (PPB) aims to restore the place of farmers in crop variety development by bringing together farmers, plant breeders and other partners in the plant breeding process.

Why PPB for organic agriculture?

- As a result of the relatively small number of organic acres, plant breeding programs have generally overlooked organic crop production systems, and crop varieties currently used in organic agriculture are bred for conventional, high-input production. Previous studies have shown that crop performance in organic systems is improved if selection occurs under organic field conditions.

Objectives of the PPB program

- To develop cultivars relevant to farmers needs by conducting selection in the farm environment
- To give farmers more control over seed resources by helping them develop and maintain their own varieties.

How does the University of Manitoba's PPB program work?

- A plant breeder makes crosses between two parental lines, with farmers having direct input into which parents are used.
    - Parents can be a registered variety or a breeding line
- Seed resulting from the initial cross is increased at the University of Manitoba
- After two generations of seed increase, third generation (F3) seed is distributed to farmers. At this point the populations are segregating, and there will be a range of characteristics to select for within the populations.
- Farmers choose the populations that they would like to grow based on the characteristics of the parental lines used to make the cross.
- The participating farmers set breeding goals and objective and make selections in their populations based on their objectives.
    - In each year of the project farmers typically select approximately 300 spikes or panicles in each population based on characteristics such as:
        - Height
        - Maturity
        - Spike/panicle appearance

    - Diseases (FHB, rust, leaf spotting diseases, etc.)
- Selected spikes/panicles are sent to the U of M for threshing and cleaning, and then are returned to the farmer for planting the following year.
- On-farm selections are made for three growing seasons. After the third year of selection the populations will be evaluated at a research farm, and the farmer can continue to evaluate the populations or increase seed on their own farms.

<u>On-Farm Plot Management</u>

Location	The populations should be planted in an area representative of the conditions where you would normally grow wheat/oats. Ideally, the populations should be grown under normal management practices
Amount of seed provided	7,000 seeds/population, enough to seed a 20 m^2 plot
Seeding	Seeding is generally done with a push garden seeder or by hand. Some farmers use modified field equipment.